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THESIS

COMPARISON OF TIME
TO DETECT DEFINITIONS

by

Laurence M. DuBois

June 1986

Thesis Advisor: Donald R. Barr

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Comparison of Time To Detect Definitions

by

Laurence M. DuBois
Captain, United States Army
B.S., California Polytechnic State University, 1976

Submitted in partial fulfillment of the
requirements for the degree of

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June 1986

ABSTRACT

This thesis concerns the measurement of times to detect multiple targets. It compares two common definitions of times to detection-- interdetection time, and search time to detection--to a relatively new definition called time in field-of-view until detection. This comparison uses the data from the Thermal Pinpoint Test conducted from July to December 1983. Detection time distributions and mean times to detection were studied, looking for patterns in the geometric ordering of targets, and in the chronological ordering of detections. Observer search scan behavior was also briefly analyzed. Mean time in field of view displayed some interesting results. Significant correlation was discovered between the mean time to detect one target and the mean time to detect the next target. Additionally, a linear trend was found in the mean time in field-of-view over chronologically ordered detections. Finally, a mathematical model was derived to explain the time to detect a sequence of targets.

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I. INTRODUCTION

A. GENERAL

The target detection phenomenon is very complex, and is influenced by many factors. Some of these factors are hard to measure in the field and some are probably impossible to include explicitly in combat models. In this analysis we study the phenomenon in a relatively new way to gain further understanding of it.

This analysis is a comparison of three methods of computing time to detection in a multiple target environment using data from a field experiment. These methods are really different ways of defining time to detection. While many search algorithms have been developed for minimizing detect time, and most high-resolution combat simulations model detect time, few analyses or models have dealt with the definition of time to detect in a multiple target environment.

The three time to detect definitions discussed here are:

1. The time interval from the last target detect to the next target detect (called detect-to-detect),
2. The time interval from the start search time to target detect (called search-to-detect), and
3. The accumulated time the target is within the observer's field of view (FOV) until detection (called FOV-to-detect).

These three definitions are explained further in Chapter III.

The purpose of this analysis is to compare a novel approach in computing time to detection, FOV-to-detect, with the two other methods which have common usage. It is hoped that the results of this comparison will help to further the understanding of the detection phenomenon and to assist combat modelers in their attempt to accurately portray detections in a multiple target environment. The idea of measuring FOV-to-detect can be accredited to analysts at TRASANA and CDEC. But to this author's knowledge, this is the first time FOV-to-detect has actually been computed using field test data.

B. SCOPE OF ANALYSIS

This analysis is limited to a comparison of three time to detect definitions in a multiple target environment. The data used in this comparison came from day trials of the Thermal Pinpoint Test. The Test basically consisted of observers and targets. The observer's mission was to search an assigned sector, detect and identify all targets, and to engage targets not yet engaged. The target's mission was to follow its assigned schedule of movement (if so designated), and simulate firing (if so designated). Of concern to the analysts designing the Test was the observer's behavior and abilities, not those of the target. In that sense, the Test was one-way. Further description of the Test is in Chapter II.

The sole concern of this study is the detection phenomenon, and the time required for the observer to first detect the target. Thus, subsequent detections were not considered. Also, not of concern in this analysis were the events occurring after each target detection and before starting to search for the next target (target recognition, aiming, and firing at the targets).

A thorough investigation of the different factors affecting time to detection and the probability of detection is outside the scope of this paper. At least two studies have already done that for the Thermal Pinpoint data. These are described below in the next section.

II. THE DATA

A. THE THERMAL PINPOINT TEST

The data studied in this analysis is from the Thermal Pinpoint Test conducted at Fort Hunter Liggett, California during the period 19 July to 10 December 1983. The Thermal Pinpoint Test was designed and conducted by the Combat Developments Experimentation Center (CDEC) headquartered at Fort Ord, California. The field test was performed in response to a need identified by the Deputy Under Secretary of the Army for Operations Analysis (DUSA-OR) for field experiments to help further the understanding of the target detection phenomenon. It was felt that special emphasis should be placed on comparing the capabilities of thermal and nonthermal sights in a ground combat environment. The Army's TRADOC Systems Analysis Activity (TRASANA) was selected to be the proponent for this test with CDEC to conduct the test and provide TRASANA with the reduced data for subsequent analysis [Ref. 1: pp. 1-2,1-3]. It was hoped that the knowledge gained from analyzing test results would not only give better understanding of detection, especially detections using thermal and optical sights. Combat modellers would also benefit.

Several studies have previously been done on this test. CDEC's Final Test Report, dated January 1984 provided TRASANA with statistical data and a complete description of the test conduct. TRASANA is on the verge of publishing its analysis of this data. In September 1985, Captain Cornell McKenzie presented a statical analysis of the data for his masters thesis in Operations Analysis at the Naval Postgraduate School. His study focused on the target acquisition capabilities of tanks--specifically, detection times and number of detections, broken down by most of the trial and environmental conditions [Ref. 2: p. 11].

B. TEST DESIGN

Consisting of 288 trials, the Thermal Pinpoint Test evaluated the behavior of six ground observer platforms (four tanks, and two TOW antitank weapons). For each trial, there were ten targets (normally four tanks, two BMPs (armored personnel carriers), two thermal tank decoys, one M48 tank, and an M551 Sheridan tank. The M48 and M551 represented dead tanks, or hulks. All targets were in hull defilade, that is, partially concealed from the observers by a hill or ground. Target positions were varied periodically between trials and selected so that line of sight existed between all observer/target pairs. [Ref. 1: pp. 2-8,2-9]

TABLE 0

TEST DESIGN MATRIX

		Range		
Trial Type		Short	Medium	Long
Day	Stationary	16	16	16
	Moving	16	16	16
Night	Stationary	16	16	16
	Moving	16	16	16
Morning	Stationary	8	8	8
	Moving	8	8	8
Evening	Stationary	8	8	8
	Moving	8	8	8
Total number of trials = 288				

Table I shows the design matrix for the Thermal Pinpoint Test. It indicates the number of trials conducted in each cell for the three major conditions: time of day, observer motion, and observer-target range. [Ref. 3: p. 3-9]

Observer stationary trials were 10 minutes in duration, with nine of the ten targets stationary. One tank or BMP was designated to move at certain periods of the trial. Observer moving trials lasted for four minutes, with some of the targets moving. In all trials, the observer crews were isolated from each other so that no target location cues passed between them [Ref. 1: p. 2-9]. Thus, each observer's behavior was independent of the others. The number of observer/trials was 1728 (288 trials x 6 observers).

Most pertinent controllable factors affecting target detection were measured, from observer sight type to visual target-to-background contrast. The test design [Ref. 3: pp. 3-2,3-4], categorized the trials, observers, and targets as follows:

1. Trial Factors
    a. Time of day (morning/day/evening/night)
        1) Morning was defined as one hour before sunrise until one hour after sunrise;
        2) Day was defined as one hour after sunrise until two hours before sunset;
        3) Evening was defined as two hours before sunset until one hour after sunset;
        4) Night was defined as one hour after sunset until one hour before sunrise.
    b. Trial site (1-9)
2. Observer Factors
    a. Observer motion (stationary/moving)
    b. Observer type (tank/TOW)
    c. Gunner sight type (thermal/optical)
    d. Hatch status (tank only: closed/open)
    e. Tank commander search mode (tank with open hatch only: sight/unaided visual)
    f. Sight FOV (thermal: 2.5 degrees and 15 degrees optical: 8 degrees)
    g. Crewmember making detection (tank cmdr/gunner)

    h. MOPP (chemical and radiological gear worn: yes/no)

3. Target Factors
    a. Observer-Target azimuth (degrees measured clockwise from grid north)
    b. Observer-Target range (between 900 and 3300 meters)
    c. Target type (tank/BMP/hulk/decoy)
    d. Target motion (stationary/moving)
    e. Camouflage (none/partial/full)
    f. Engine status (off/running/ N/A)
    g. Target-Background temperature contrast level
    h. Target-Background visibility contrast level
4. Environmental Factors
    a. Times of sunrise, sunset, sulnset, moonrise, and moonset
    b. Air temperature
    c. Relative humidity and dewpoint
    d. Windspeed and direction
    e. Visibility and cloud cover
    f. Other weather related factors

C. SEQUENCE OF TRIAL EVENTS

While various conditions were varied between trials, all trials had the same basic sequence. All primary test design variables (time of day, range, observer motion, hatch status, MOPP status, and sight type) were held fixed throughout the trial [Ref. 3: p. 2-10]. The following is a list of possible events that were recorded for each observer in a trial.

1. Tank crew begins searching for targets. The tank commander (TC) is normally in control of slewing the turret.
2. If the hatch is open, the TC can, at any time, alternate back and forth between the tank sight and looking out the hatch (with or without binoculars). If the TC uses the sight, he has the same sight picture as the gunner.
3. If the sight type is thermal, the gunner can, at any time, alternate the FOV between narrow (2.5 degrees) and wide (15 degrees). The optical sight FOV is constant at 8 degrees.

4. Either the gunner or the TC detects a target. The crewmember making the detection is recorded.

5. The type of detection cue, if any, is identified (target moving, firing, etc.)

6. Either the gunner or the TC recognizes the target as false target, hulk, decoy, or a valid target. The claimed target type is recorded.

7. If the target is valid and has not yet been fired on by that observer, then the TC directs the gunner to aim and fire (simulated). Since no actual rounds were fired, no casualty assessment was made by the crew.

8. The crew begins searching for another target. The sequence continues until trial end.

D. LIMITATIONS OF THE THERMAL PINPOINT TEST

Any time a controlled field test tries to simulate live combat, there will be some lack of realism. Stress is known to be a major factor in proficiency. Test conditions such as smoke, artillery simulators, and blank ammunition which were employed in the Thermal Pinpoint Test probably instilled only a small degree of combat stress in the observers. The results of the test must be weighed accordingly. More likely, an element of boredom set in over the period of the 288 trials. Learning the "tricks" of the test surely occurred, such as learning target placement patterns, and learning to recognize quickly the four target types used throughout (tanks, BMPs, hulks, and decoys). For this reason, the last quarter of the trials are probably less meaningful than the rest.

Climate conditions at Fort Hunter Liggett varied considerably over the duration of the test (July to December) and environmental conditions were recorded for each trial. The hot summer drought and the wet fall are quite different from other climates. Care must be taken in applying these results to other areas, seasons, and conditions.

In view of the scope of this analysis, one minor limitation to the Thermal Pinpoint Test was that the number of targets was not varied. It is intuitive that a very important factor affecting time to detection is the number of targets within range and line of sight. One might reason that as the number of targets increases so does the time to detect all targets. It is also reasonable to believe that the time between detections would decrease because there are more targets and some are therefore easy to find. In order to test this theory directly, trials with five and fifteen targets might have been included in the Thermal Pinpoint Test, rather than having ten targets in all the trials.

III. DATA MANIPULATION

A. DEFINITIONS OF TIME TO DETECT

There are two commonly used methods of measuring time to detection and a relatively unexplored third method:

1. Lapsed time between detections, detect-to-detect (hereafter called DETDET),
2. Lapsed time from start of search to detection (hereafter called SEARCHDET),
3. Accumulated time the target is within the observer's FOV until detection (hereafter called FOVDET).

To better understand the differences between these methods, we will compare them in measuring the same hypothetical trial. Let the trial duration be 180 seconds, and let us assume there is one stationary observer and three stationary targets of equal priority within the observer's line of sight. The sight he uses has a defined field of view and at every second of the trial, the sight azimuth is recorded. Also recorded are the times of search start, target detection, target recognition, aiming, and firing. Figure 3.1 depicts the three methods for the hypothetical trial.

1. DETDET

Otherwise known as interdetection time, DETDET is the easiest to compute. Many combat models use this definition of time to detect, at least indirectly. Most Army high-resolution combat models use the Night Vision and Electro-Optics Lab (NVEOL) detection model. Briefly stated, it computes the probability of target detection P, in time interval t, by the formula:

$$P = P [(1-\exp(-t/)]$$

where P is the probability that the target will be found in an infinite time, and is the mean time to detection (DETDET), for those targets detected. Note that the model

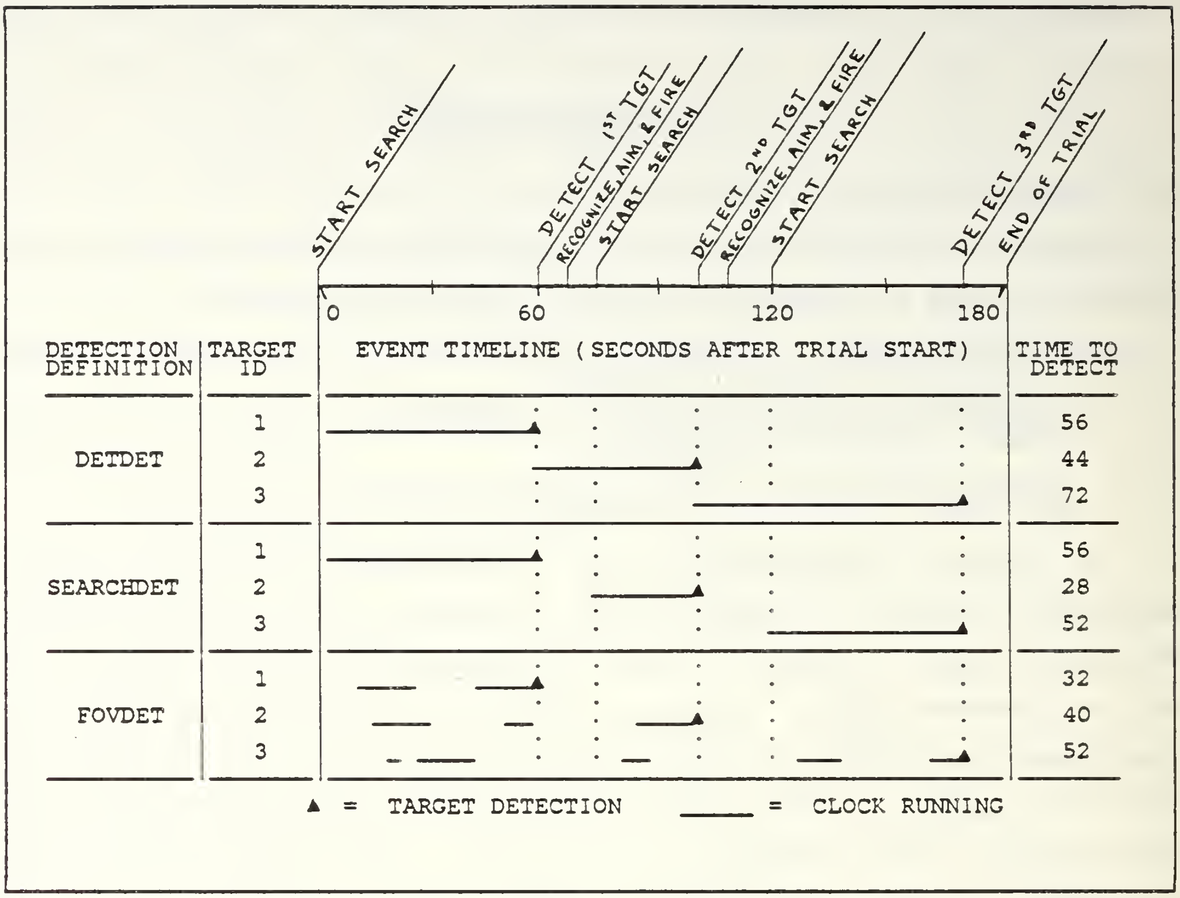


Figure 3.1 Diagram of DETDET, SEARCHDET, and FOVDET In a Hypothetical Trial

does not predict target detect time. Instead, it uses a given mean time to detect to predict probability of detection by time t. Further discussion of the NVEOL model can be found in [Ref. 4: pp.2-7].

2. SEARCHDET

SEARCHDET is the same as DETDET except it does not include the interval the observer spends between detection and starting to search for another target. This interval includes recognizing the target as friend or foe, aiming at the target (and other preparation for fire steps), firing at the target, and casualty assessment. SEARCHDET is often seen as more appropriate than DETDET because it only counts the time the observer is actually searching. Notice in Figure 3.1 that from trial start to the first detection, SEARCHDET is the same as DETDET. With that exception, the SEARCHDET time is lower than DETDET. Both CDEC's Final Report and McKenzie's thesis used the SEARCHDET definition in their analyses.

3. FOVDET

FOVDET goes one step beyond the SEARCHDET method. It only counts the time the observer is searching and looking in the "direction of the target". Here, "direction of the target" is defined as within the observer's FOV. Figure 3.1 indicates that FOVDET is not consistently more or less than either DETDET or SEARCHDET. This method is by far the hardest to calculate, which is likely the reason that few analyses appear to have used it. Another reason is that it requires more instrumentation in the field test than the other methods.

It is interesting to note that NVEOL has conducted several experiments studying FOV and its affect on target detection. Their results indicated, as did McKenzie, that mean time to detect and FOV were inversely related. However, no FOVDET computations were made.

B. FOVDET CALCULATION

While DETDET and SEARCHDET are readily available from the data and little computation is necessary, FOVDET is another matter. To illustrate how involved the FOVDET computation is, we return to our hypothetical trial. Imagine at each of the three targets there is a clock that accumulates the duration that it comes within the observer's FOV. As he scans the battlefield, in effect, the observer is "illuminating" the area with a FOV "beam". As a target is illuminated, its time counter is activated, like a solar powered clock, until the illumination departs. This "target clock" accumulates the total time it is illuminated until the target is detected for the first time. (Subsequent detections of the same target are not considered in this analysis.) Because the observer's search pattern is somewhat random, this "target clock" could be activated several times over the course of the trial.

In our hypothetical trial, both the observer and the target are stationary and targets are assumed to be of equal priority to the observer. The observer engages targets as he detects them, so it is unnecessary for him to redetect the target later.

To compute a target's time within FOV, the following information is required at one second intervals throughout the trial:

1. the observer X,Y position coordinates,
2. the target X,Y position coordinates,
3. the observer's sight azimuth,
4. the observer's FOV in degrees.

From the X,Y coordinates, the observer-target (OT) range and azimuth are calculated from the formulas:

$$\text{OT range} = \quad (Xobs-Xtgt)^2+(Yobs-Ytgt)^2$$

If Xtgt > Xobs then: $\text{OT azimuth} = 90-(\arctan(A) \times 180/\quad)$

If Xtgt $\leq$ Xobs then: $\text{OT azimuth} = 270-(\arctan(A) \times 180/\quad)$

where A = (Ytgt-Yobs)/(Xtgt-Xobs),
Xobs and Yobs are the X and Y coordinates of the observer,
and Xtgt and Ytgt are the X and Y coordinates of the target.

The OT azimuth is needed to compare to the observer's sight azimuth to determine if they are within plus or minus half of the observer's FOV angle.

For example, if at a given point in the trial, the observer-target azimuth is 280 degrees, and the observer is using his wide angle FOV (15 degrees), and the observer's sight is pointed at 286 degrees, then the target is within the observer's FOV. This procedure is repeated for every second of the trial until detection (or until end of trial if the target was not detected).

In our hypothetical trial, there is one observer and three targets. Therefore three "target clocks" are being "illuminated" separately, resulting in three separate FOVDET computations. The volume of FOVDET computations in the Thermal Pinpoint Test, required a massive amount of computer time and space. For every usable observer/trial, the FOVDET computaion had to be repeated 5400 times (600 seconds trial duration x 9 targets). From the above four data requirements and the amount of calculations involved, it is easy to understand why the FOVDET measure has not been widely utilized.

C. DATA DELETIONS

Because of the data requirements to compute FOVDET, much of the Thermal Pinpoint data had to be deleted. The deletions mentioned here were not due to errors in collecting data. They result from the data prerequisites to compute FOVDET. A discussion of data errors is in the next section.

The most limiting prerequisite was the need to have continuous and accurate position location (PL) data for observers and targets. For all observer moving trials, observer PL data were recorded only at the time of trial start. Therefore all those trials were deleted from this analysis, cutting the number of trials from 288 to 144.

The requirement for PL data also caused the deletion of the one moving target in each observer stationary trial. As with moving observers, PL was recorded (in the data set) at trial start only, and there was no accurate way to compute the target's PL from information in the data set. Thus, only nine targets were considered in this analysis.

The next most limiting requirement was to have nearly continuous sight azimuth data recorded for the whole trial.

With sights boresighted to the main gun, CDEC was able to instrument the observer tanks to record the tube azimuth. In the observer stationary trials, the tank azimuths were recorded every .25 seconds of each 600 second trial. A decision was made by TRASANA that, to satisfy their analysis, only one azimuth recording per second would be retained. Of more impact was that azimuth instrumentation for the TOW observers was not feasible [Ref. 1: p. D-1]. Therefore, all TOW data had to be deleted from this analysis. This dropped the number of observer/trials from 864 (144 trials x 6 observers) to 576. These first two data restrictions alone have forced deletion of two thirds of the data.

Approximately 14 percent of all observer/trials had to be deleted because of lack of tube azimuth data. In most cases, this was due to instrumentation problems with one of the observers. Some trials, however, were totally without azimuth. The number of stationary observer/trials was dropped from 576 to 492.

There was another area where the sight azimuth requirement caused data deletions. One percent of the observer/trials were deleted because of unknown TC search mode (sight/unaided visual) when the tank hatch was open. There was no way to tell if the TC was using the sight or searching out his hatch. Also, in the rare cases where the observer's hatch was open, and the TC was standing in the hatch searching for targets (either unaided or with binoculars), and the crewmember calling the detection was the TC, then that engagement was deleted. In that case, there was no way to know in what azimuth he was looking (much less his FOV).

D. ACURACY OF THE DATA

Fortunately for this analysis, accuracy in the observer's FOV was considered important for the Thermal Pinpoint

Test. Significant effort was made in insuring sights were correctly boresighted, and remained so during the trial. The same was true of insuring the calibration of the Gun Azimuth System (GAS) to within .5 degrees. The GAS is the system that recorded the tank tube azimuth. [Ref. 1: p. H-20]

Assuming observer-target line of sight existed, and assuming the observer crew could detect a target just as well anywhere within its FOV, any target falling within half a FOV of the sight azimuth was detectable. In the course of preparing the computer programs to compute FOVDET, this author noticed several instances where a target was detected , yet no time within FOV had accumulated. This obviously indicated error somewhere. Further investigation uncovered there were significant differences between the OT azimuth and the azimuth at detect time.

Intuitively, the distribution of detected target locations within the observer's sight at detect time should center around zero (sight pointed directly at the target),ie the expected value E[OT azimuth - detect azimuth] = 0. In about 75 percent of the detections, this proved to be the case. Those were roughly normally distributed with a standard deviation of about one degree. However, 15 percent of detections occurred outside the FOV. The azimuth errors (difference between OT azimuth and detect azimuth) were of three types: spikes, azimuth bias, and random error. The cause of each type and its possible correction is discussed below.

Spikes were sudden jumps where the turret azimuth was recording good azimuths, then supposedly shifted 100 or more degrees in one second, and then back to normal the next second. It is obviously impossible for a tank turret to do this. The spikes were probably caused by surges in the power source, or from dust in the environment. No correction was made of these extreme spikes because their relative frequency was so small--approximately .1 percent of the azimuths. These spikes did affect the FOVDET computation, but only by two or three seconds and only in a small number of trials. Had they been signicant, a simple smoothing technique could have been applied to the azimuth data.

Observer bias was defined as azimuth errors consistently positive or consistently negative for an observer over the whole trial. These errors were very likely caused by a minor inaccuracy in the calibration of the turret prior to trial start. The apparent biases were corrected by adding or subtracting an appropriate amount so that the differences centered around zero. Approximately 9 percent of the observer azimuths were corrected, most by .5 degrees and none more than 1.5 degrees.

Random differences between OT azimuth and detect azimuth of more than half FOV were not correctable. About ten percent of the azimuths of these random errors were over half the FOV. The larger deviations might be explained by incorrect target identification--especially where laser pairing did not occur between the observer and the target. In the Test, a coded laser signal was sent out when each observer pressed the trigger to fire. If the laser beam hit a laser sensing device on the target, then the identifications of both firer and target were recorded, as well as the time. This is laser pairing. It is considered the fastest, most accurate, and most preferred method of target identification. If a target detection was claimed by the observer but was not substantiated by laser pairing, then post-test determination had to be made of the identification of the target of intent. In these cases, CDEC analysts attempted to reconstruct the trial by viewing video (from a camera that was tube boresighted next to the sight), listening to recorded crew conversations, and checking the azimuth record. If target identification was not possible, then the detected target was designated "unknown" [Ref. 1: pp. A2-3,A2-4]. About 57 percent of all detections were thus designated by CDEC. It is very possible that, upon reconstruction, the wrong target was identified in ambiguous cases. In this analysis we are looking only at detections of known targets, but the FOVDET calculation uses all the observer's scan azimuths in a trial. Thus, after the FOVDET calculations were made, all "unknown" target engagements were deleted.

E. COMPUTER PROGRAMS

Five computer programs were written in SAS to convert the raw data into usable data sets and to compute the pertinent variables. The Statistical Analysis System (SAS) is a very powerful language and statistical package. Both the SAS users guides "Basics" and "Statistics" were extremely useful during the months of programming for this analysis. The raw data used in this analysis were located in the computer's mass storage at The Naval Postgraduate School. Separate raw data files existed for the data for each primary design factor: trial time of day (morning, day, evening, and night), and observer motion status (stationary and moving). The SAS programs were designed to operate on one of these files at a time. [Refs. 5,6]

The five programs appear in the appendixes and are briefly described below:

1. AZIMTEST, the simplest of the programs, accessess the observer scan azimuth data and assigns a variable name to each azimuth of the 600 second trials.
2. FOVALL computes a 600 element vector of FOVs for each observer.
3. OTAZ computes the observer-target azimuth and range, and orders the targets from left to right.
4. DETECTALL reads all the trial, observer, target, and environmental factors and prints them in readable format.

5. TIMINFOV is the workhorse program. It reads the SAS data sets created by the four previous programs and computes, among other values, DETDET, SEARCHDET, and FOVDET. It produces most of the histograms used in this study. The tables of correlation coefficients and other statistics were also produced by this program. Also computed was another value of interest--the number of times the target came into the observers FOV until detection. Obviously a close companion to the time in FOV, this holds a potential for future analyses.

IV. ANALYSIS

A. ASSUMPTIONS

With the exception of the biased observer azimuth data, which was corrected, the assumption is made that the Thermal Pinpoint data provided by CDEC was accurate. The majority of the analysis was done with pooled data, to understand detection as a whole, not to test the affect of each factor. As a result, sample size was sufficient, except where noted, to minimize the the effect of the minor inaccuracies found.

B. GEOMETRIC DISTRIBUTION OF TARGETS

In the Thermal Pinpoint Test, an artificiality existed at the beginning of each trial. In order to keep observers from viewing the search area ahead of trial start, test controllers insured that each observer's tube (and sight) was pointed to the left, well outside of the assigned search sector. This orientation ranged from 2 to 65 degrees to the left of the search area, but over 60 percent of the time, the offset was between 20 and 30 degrees. While solving the one problem, this offset created the artificiality that all observers had to traverse right before starting their search for targets.

1. Distribution of First Detections

This leads one to wonder if the left-most target would have a higher incidence of being the first target detected. So the target detections were sorted by OT azimuth (left to right). Position is defined here, not as X,Y positions, but as the relative position (left to right) from the observer's point of view. Figure 4.1 shows the distribution of the first target detected in each observer/ trial for positions 1 through 9. The left-most target was the first target detected 35 percent of the time. Also,

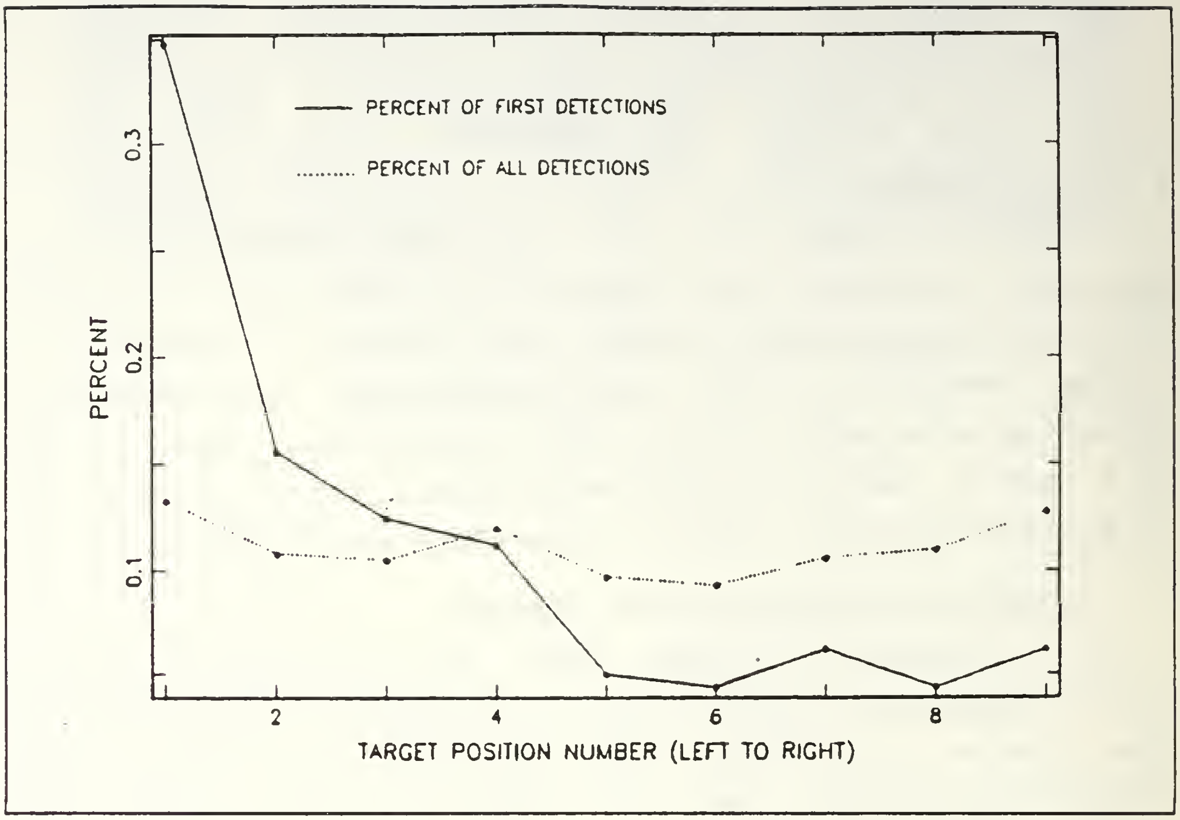


Figure 4.1 Distribution of First Detects by Position

percent of the first detections were in the four left-most targets. The graph shows the dramatic affect the pretrial azimuth orientation had on target detection. This is seen by this author as a flaw in the test design because relative target location was not a design consideration. It is likely that none of the target factors were evenly distributed by position. Only target factor was checked in this analysis--target type. Figure 4.2 shows the relative distribution of target types by position. The different shades show the percentage of time each target type occurred at the positions 1 through 9. No target type was even remotely uniformly distributed.

Returning to Figure 4.1, it also shows the percent of all target detections at each position. The dotted line indicates that, despite the skewness of first detections,

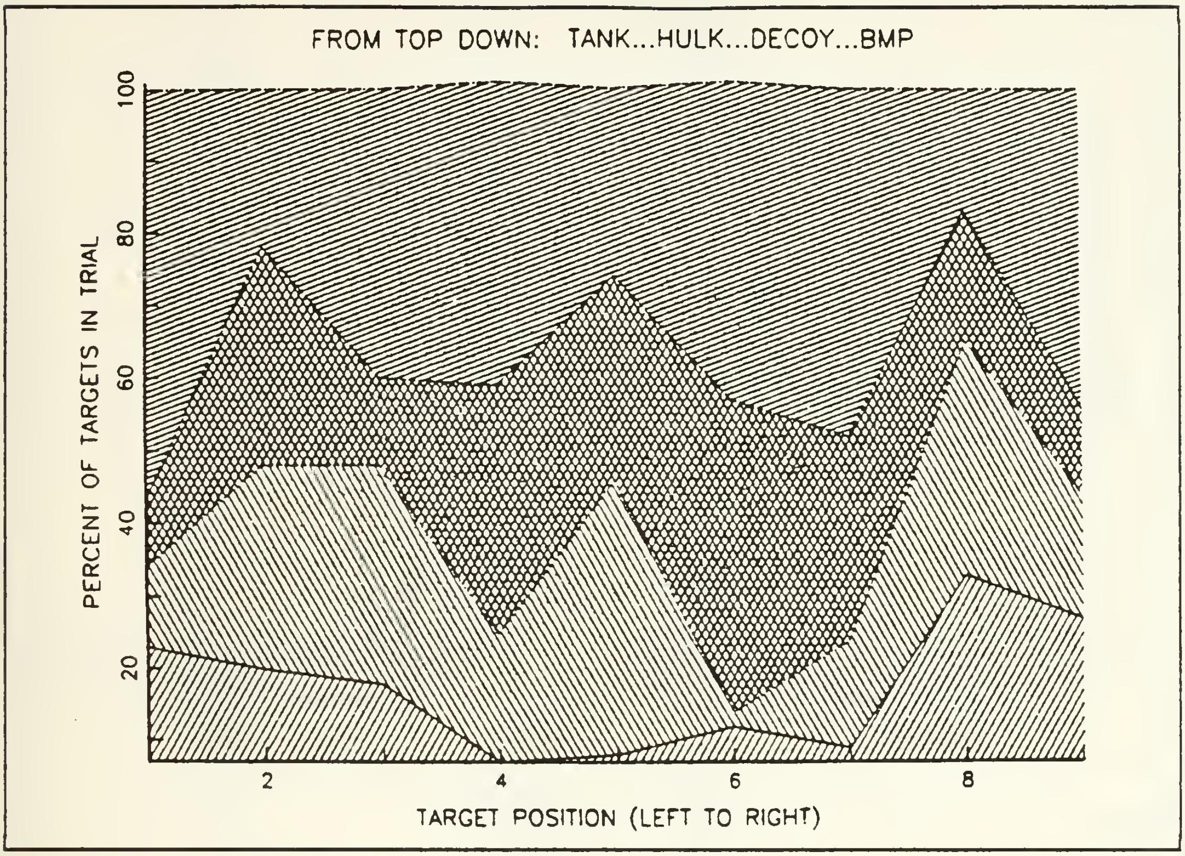


Figure 4.2 Relative Distribution of Target Types by Position

the number of detections were relatively evenly spread across all nine positions.

2. Distribution of Time to Detect

The times to detect are now examined by position for FOVDET, SEARCHDET, and DETDET. Histograms showing the distributions are in Figures 4.3, 4.4, and 4.5. Times to detect each target for all three definitions appear exponential. For FOVDET, slightly shorter detect times are shown at position 1. Positions 2 through 9 all have roughly the same distribution. SEARCHDET times are slightly shorter for position 1, but like FOVDET, show consistency in the other positions. DETDET shows slightly increased detect times at position 4 but the rest seem consistent.

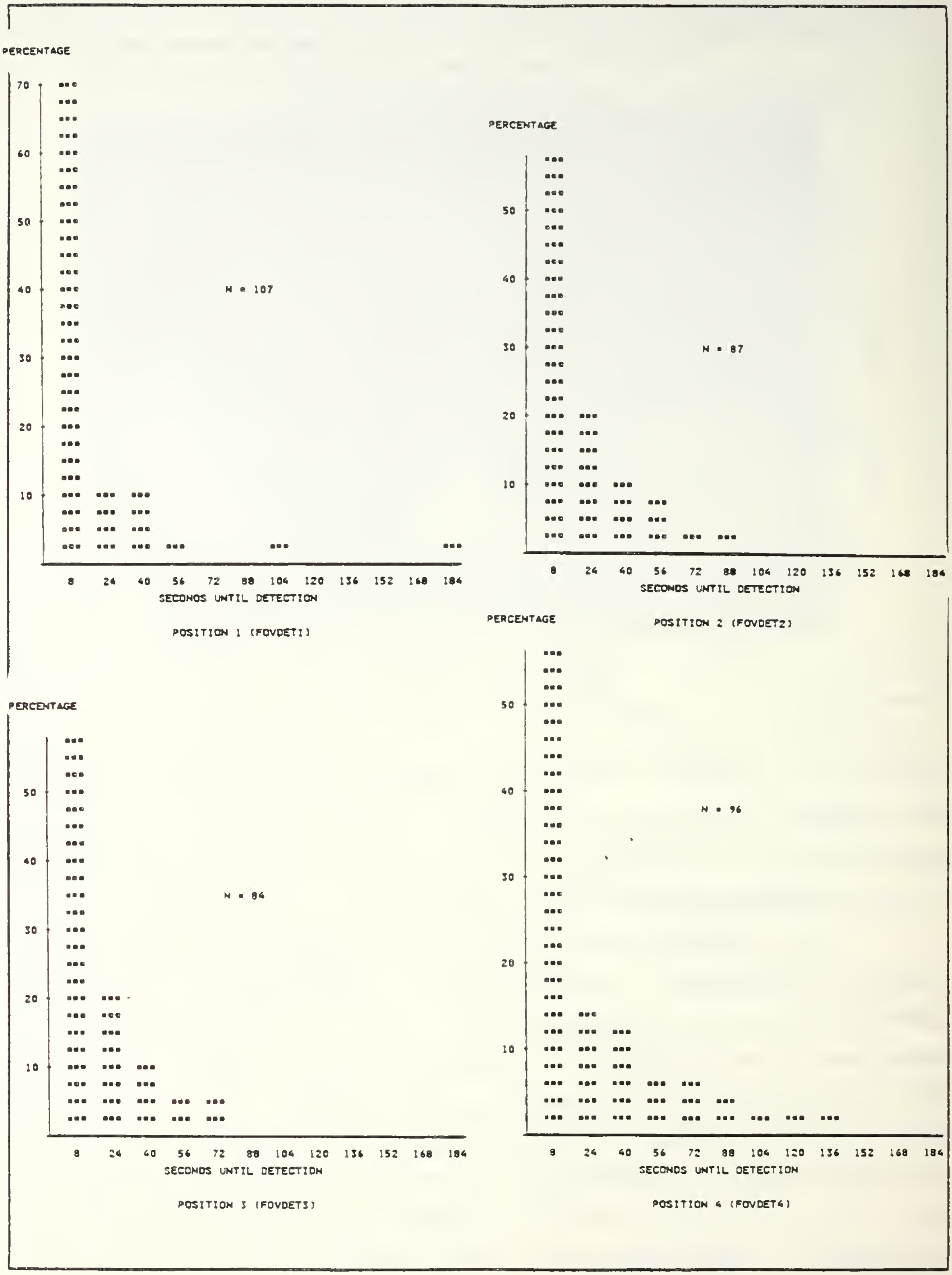


Figure 4.3a Distribution of Detect Times
Positions 1-4 (FOVDET)

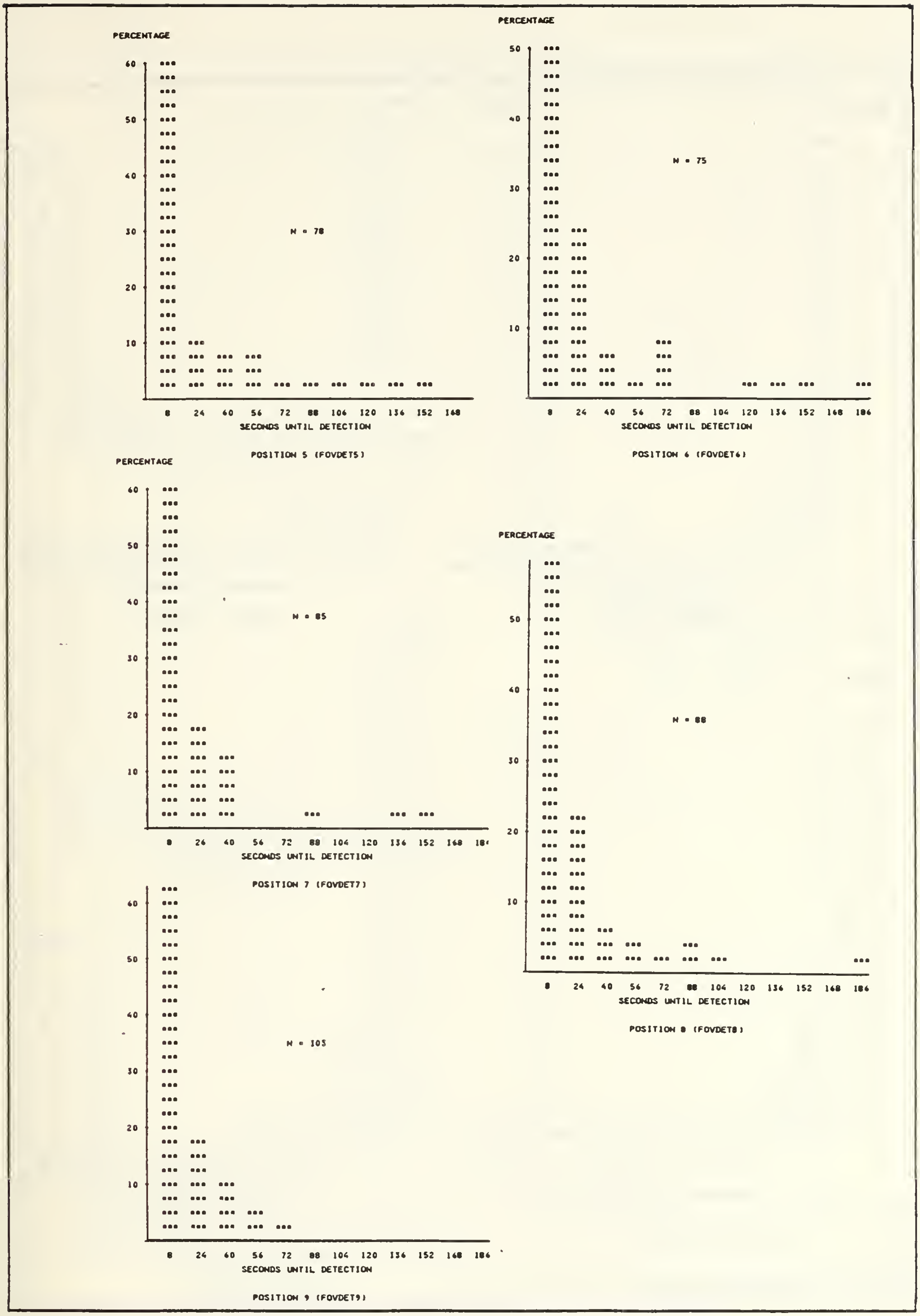


Figure 4.3b Distribution of Detect Times
Positions 5-9 (FOVDET)

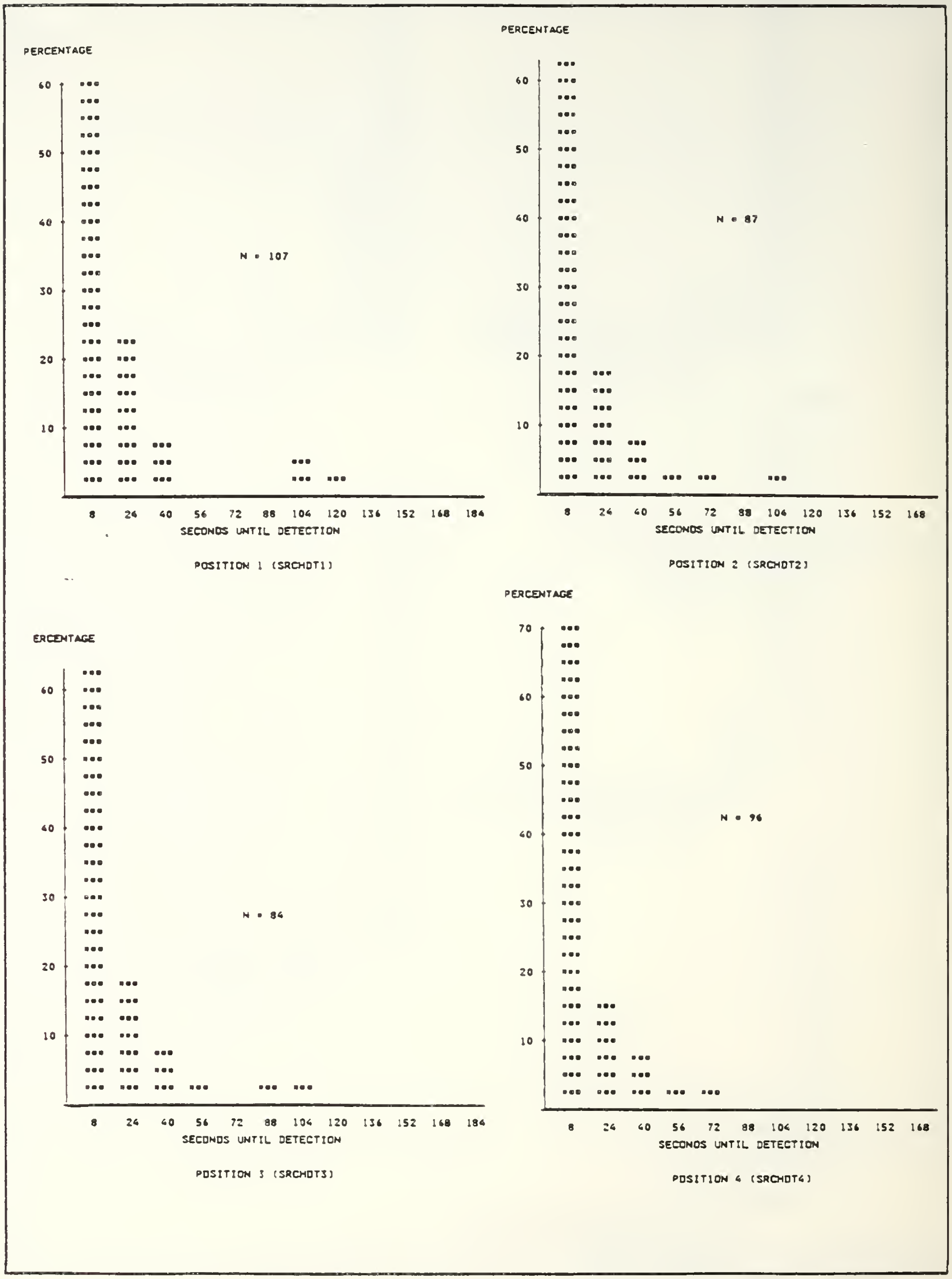


Figure 4.4a Distribution of Detect Times
Positions 1-4 (SRCHDT)

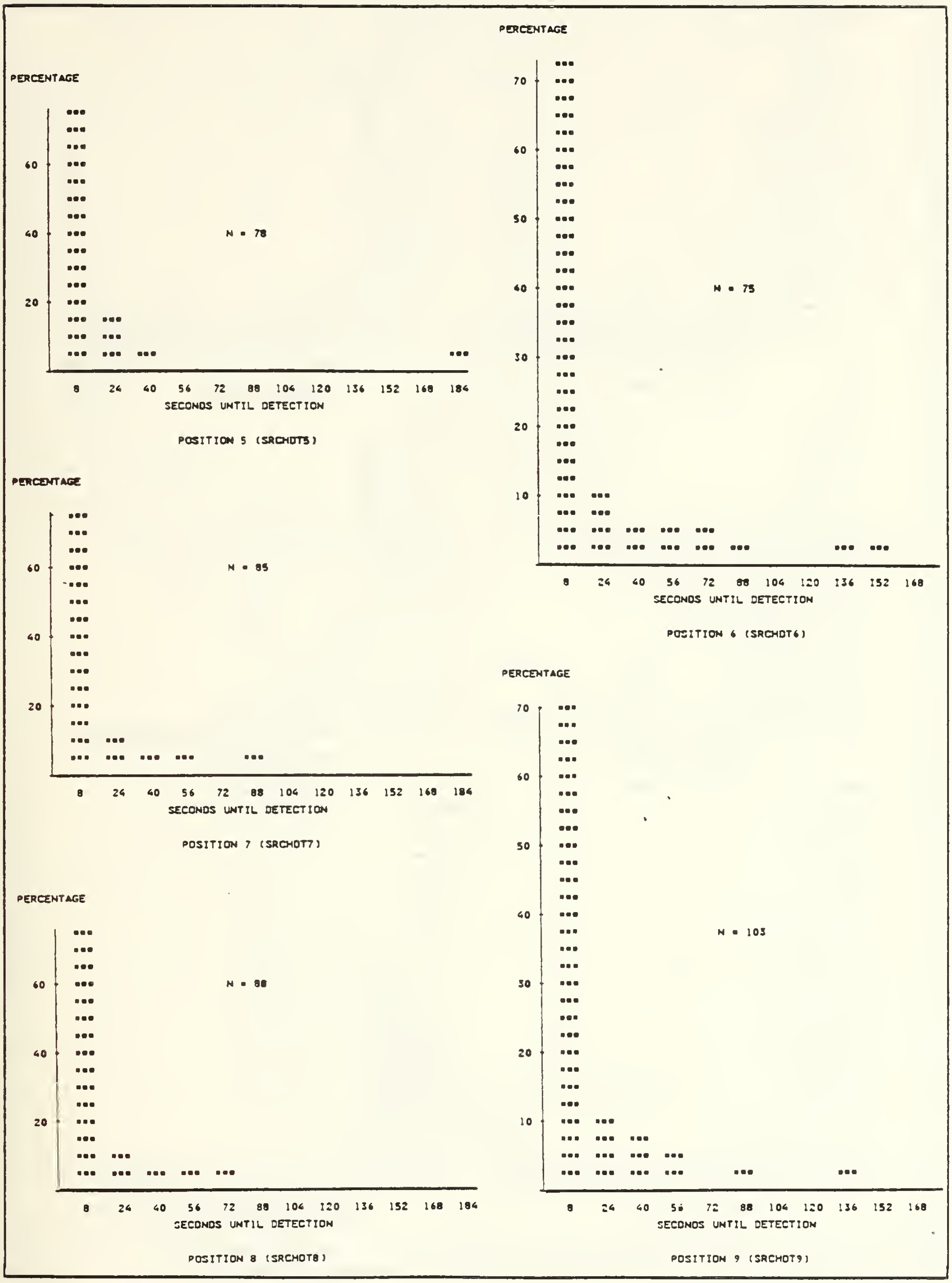
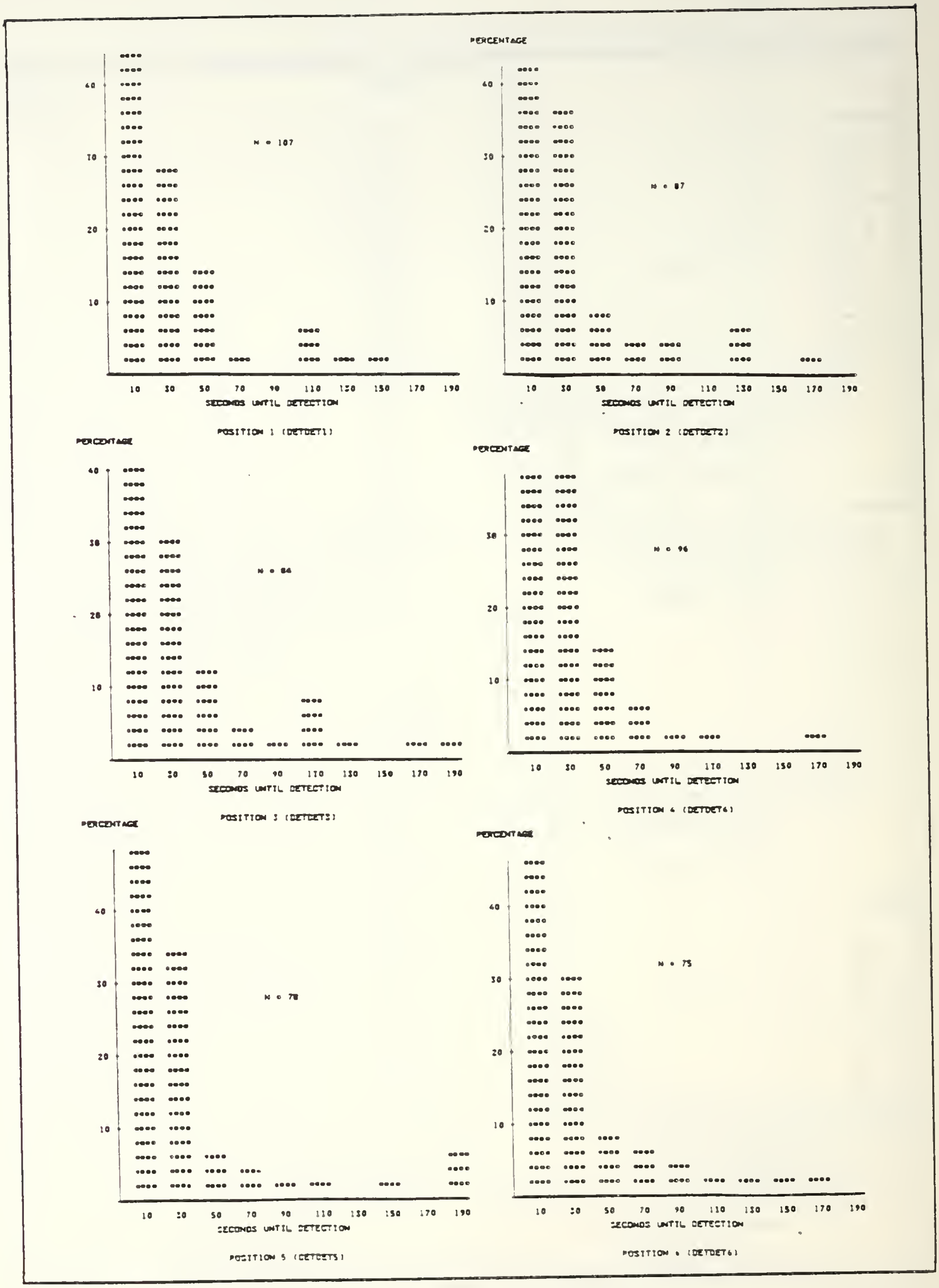


Figure 4.4b Distribution of Detect Times
Positions 5-9 (SRCHDT)



POSITION 1 (DETDET1)

POSITION 2 (DETDET2)

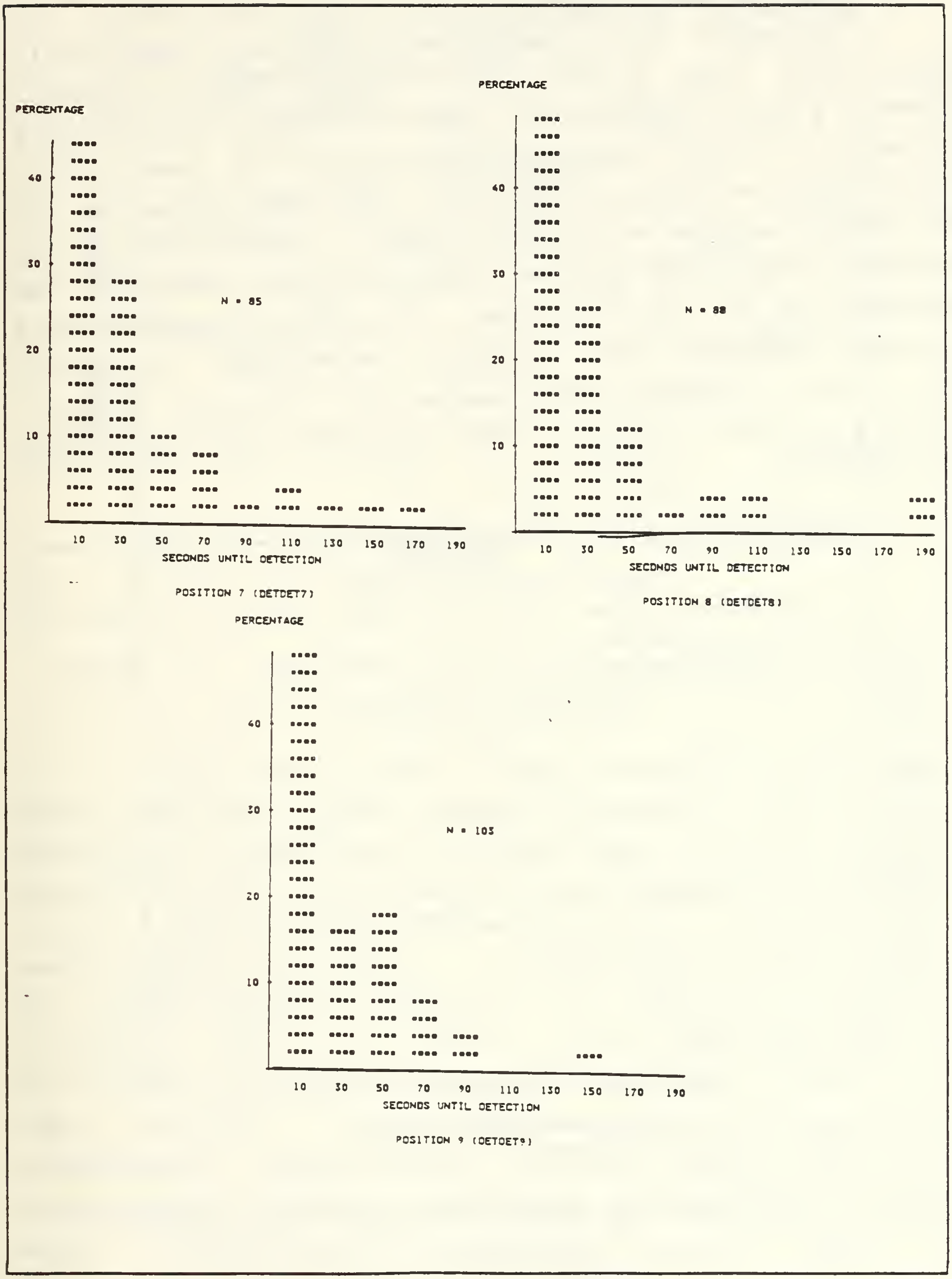
POSITION 3 (DETDET3)

POSITION 4 (DETDET4)

POSITION 5 (DETDET5)

POSITION 6 (DETDET6)

Figure 4.5a Distribution of Detect Times Positions 1-6 (DETDET)



POSITION 7 (DETDET7)

POSITION 8 (DETDET8)

POSITION 9 (DETDET9)

Figure 4.5b Distribution of Detect Times
Positions 7-9 (DETDET)

3. Mean Times To Detect

An easier way to determine trends for these positions is to look at the plot of mean times to detect. Figure 4.6 shows FOVDET mean times to detect, the standard deviation, and the standard deviation of the mean. This graph indicates shorter time within FOV until detection for the targets located at either extreme. This is intuitively pleasing because the observer spends less time searching the extremes than he does the center. To better understand this discovery, observer search behavior was studied. A discussion of the behavior is presented in the next section. Figure 4.7 shows the mean times to detect for both DETDET and SEARCHDET.

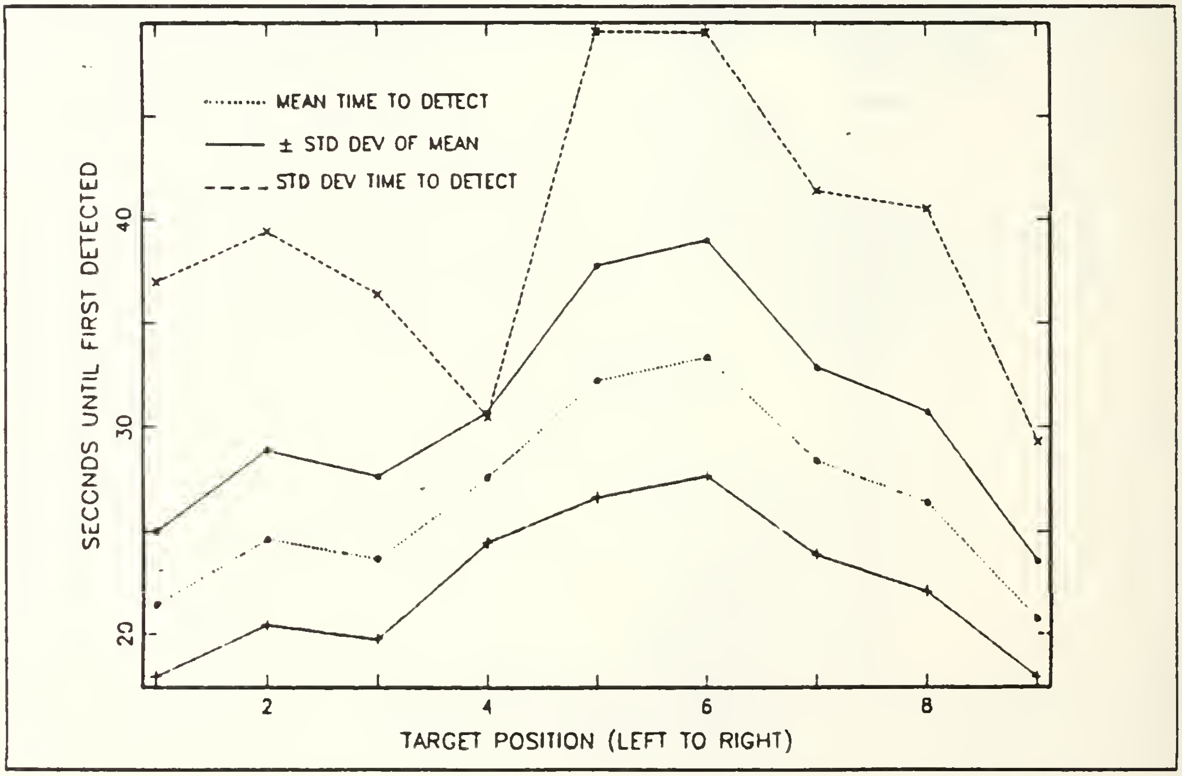


Figure 4.6 Mean Time Detect Each Target by Position FOVDET

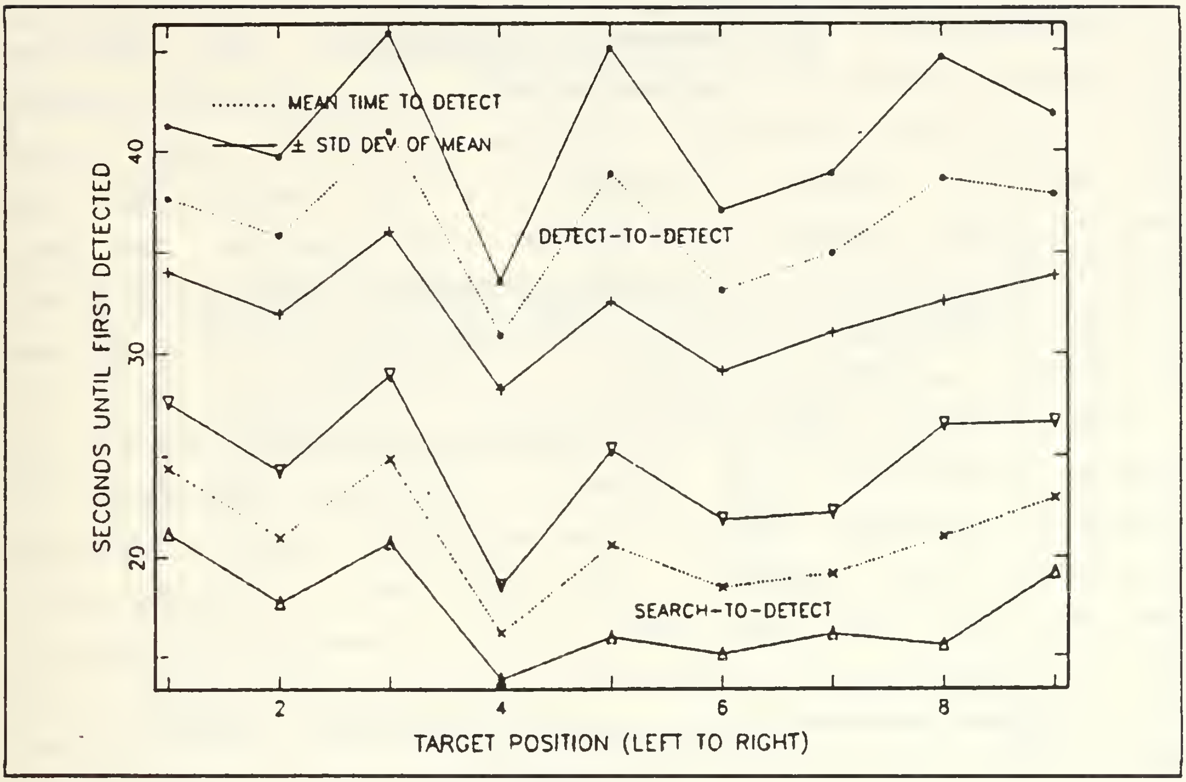


Figure 4.7 Mean Time Detect Each Target by Position DETDET and SEARCHDET

It is obvious that in the Thermal Pinpoint Test, these two times were strongly related. The average separation of mean time between the two methods is 15 seconds. Recall the difference between DETDET and SEARCHDET is the interval between target detection and starting to search for the next target. In the Thermal Pinpoint Test, the average period to recognize, aim, and fire were almost constant. Because no actual rounds were fired by the observers, no casualty assessment was made. In a real combat situation, it is expected this period would vary considerably. After firing, assessing damage done to the target might indicate to the firer that he needs to fire again. Reengagements would significantly expand the difference between DETDET and SEARCHDET.

C. OBSERVER SCAN BEHAVIOR

To understand the detection phenomenon, the observer scan behavior must also be studied. If an observer spends most of his time searching outside the target area, this will skew the times to detection. An analysis of the observer sight azimuth data showed scan behavior had some interesting patterns, as described below. Figures 4.8 and 4.9 depict the scan patterns of the four tank observers from two randomly selected day trials.

The pretrial azimuth orientation discussed above was briefly studied for its affect. Observers averaged 10 seconds to traverse right to the assigned search area from their trial start azimuth. The first ten seconds of each trial were left off the graphs to give them higher resolution. Between the two horizontal lines in Figures 4.8 and 4.9, all nine stationary targets were located. This "target band" averaged 10 degrees in azimuth width for the different trials. The pair of consistently spaced jagged lines indicate the sight azimuth ± half the FOV. The periods where the jagged lines are horizontal for several seconds normally indicates target detection. Theoretically, these detections should all be within the target band. In those cases where the apparent detection occurs with the FOV completely outside the band, the observer was detecting false or unknown targets. Where the FOV remains for long periods outside the target band, this could have been due to observer disorientation. When a FOV is as narrow as 2.5 degrees, it is very easy for the observer to lose a sense of direction and forget where the area of interest lies.

An interesting phenomenon can be seen in some of the patterns. Between 200 and 300 seconds into the trial, many observers began broad back-and-forth scanning of the search sector. The reason for this is conjecture, but they may have thought they had detected all the targets. Actually,

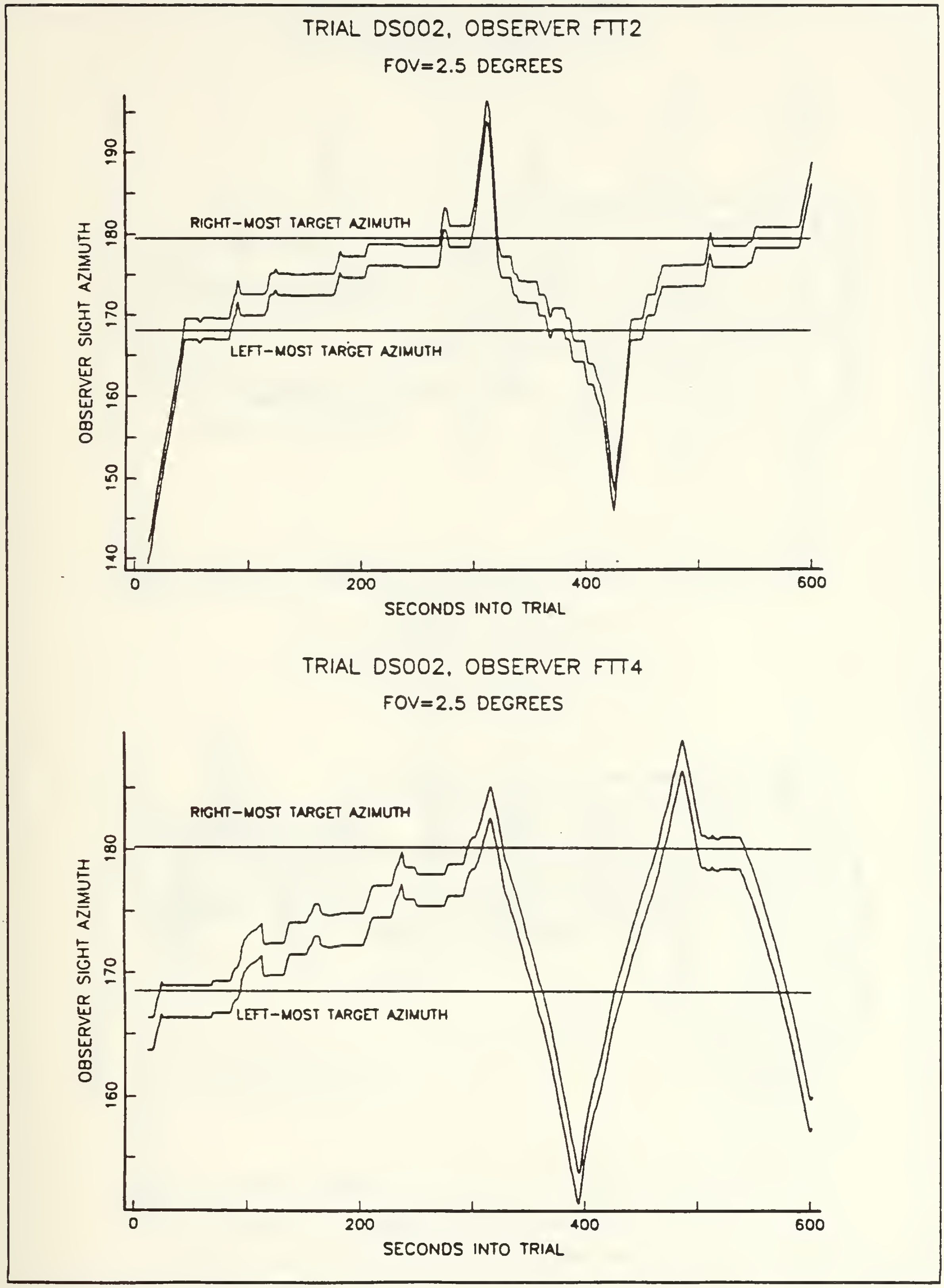
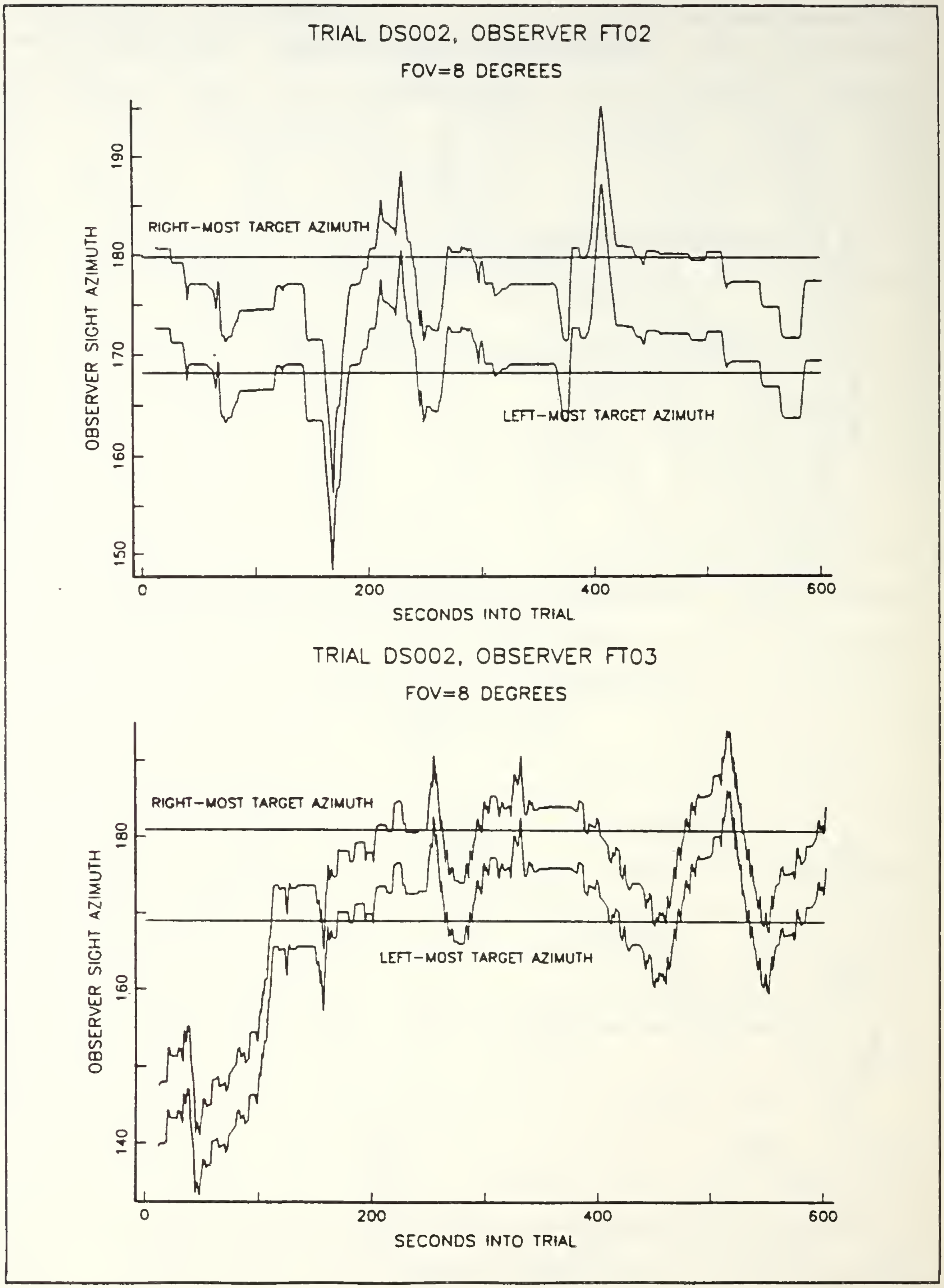


Figure 4.8a Observer Scan Behavior, Trial DS002



TRIAL DS002, OBSERVER FT02
FOV=8 DEGREES

TRIAL DS002, OBSERVER FT03
FOV=8 DEGREES

Figure 4.8b   Observer Scan Behavior, Trial DS002 (Continued)

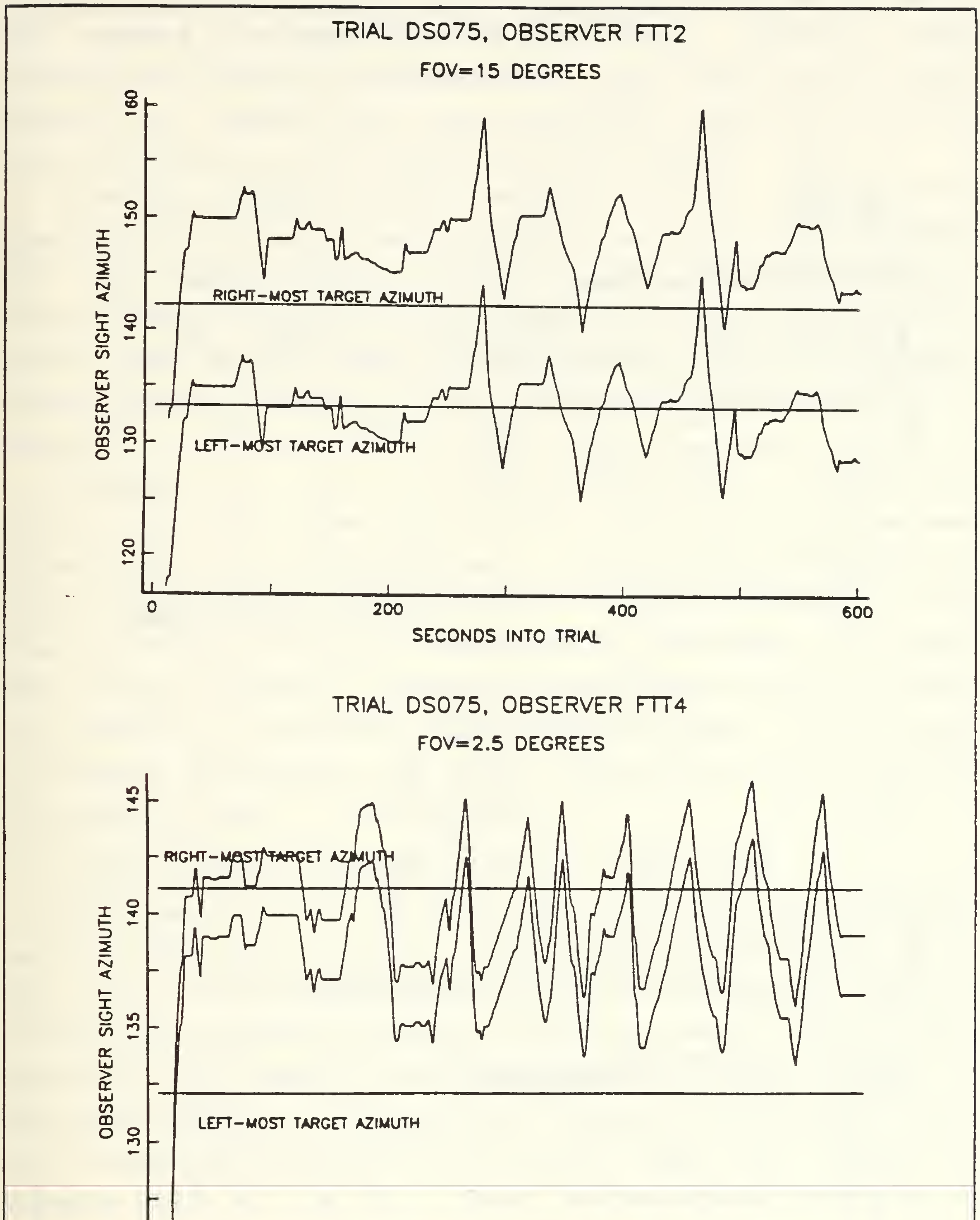


Figure 4.9a Observer Scan Behavior, Trial DS075

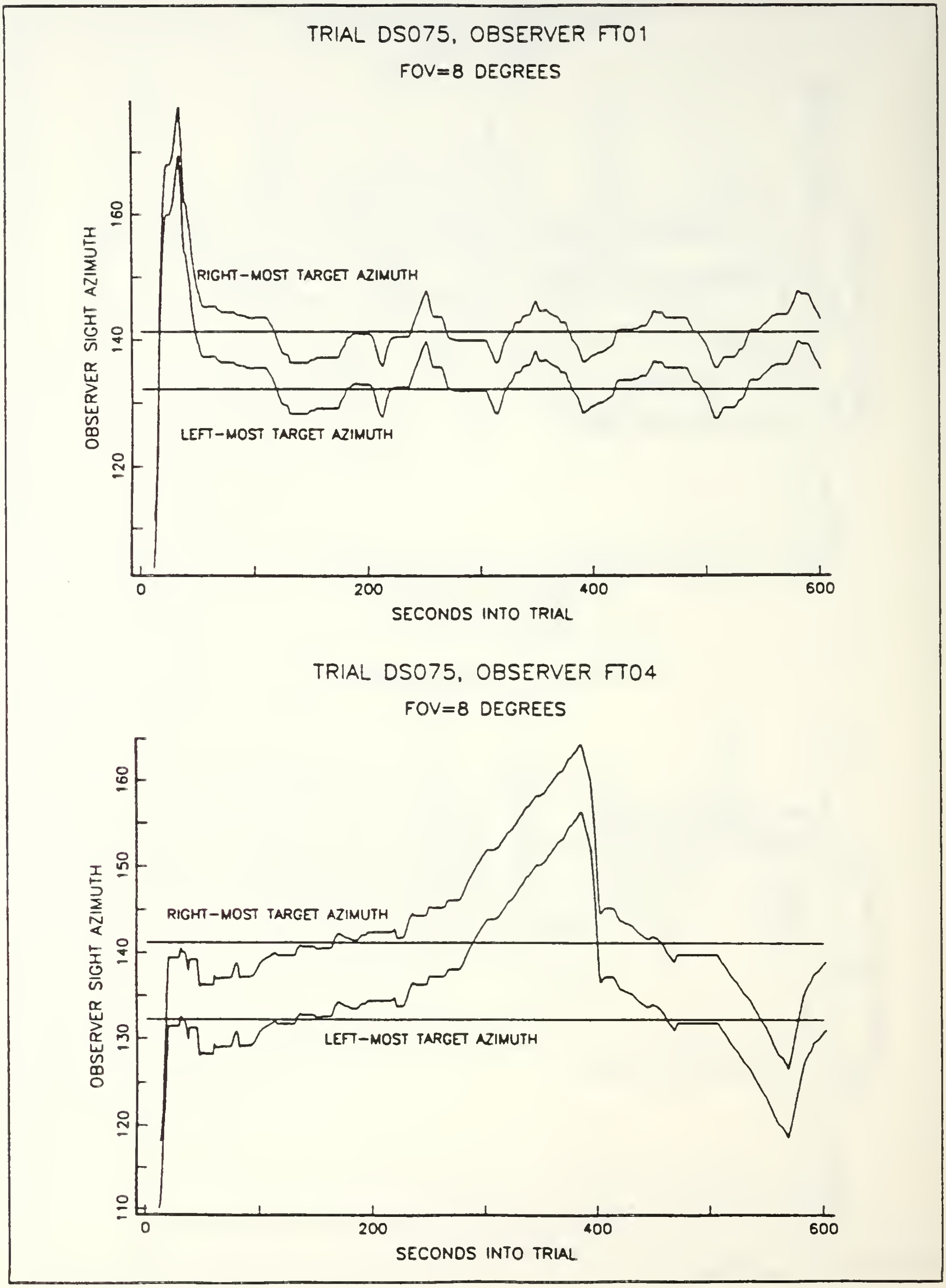


Figure 4.9b Observer Scan Behavior, Trial DS075 (Continued)

in only .5 percent of the trials did an observer detect all ten targets (including the moving one). Between broad scanning and search disorientation, the long periods spent outside the target band help to explain some of the high times to detection seen later in this chapter.

From the graphs of scan behavior, it is apparent the impact of FOV size had on computing the target's time within FOV. The Thermal Pinpoint data indicated the observers with thermal sights preferred the narrow FOV over the wide FOV. Recall that at any time, the observer crew could change between narrow and wide. Observers used the narrow FOV (2.5 degrees) some 82 percent of the time.

Figures 4.10 and 4.11 show histograms of the scan behavior for the same two trials. They picture the same azimuth data in a different way, allowing the reader to see how the azimuths were distributed. In the histograms, the black inverted triangles indicate the left-most and right-most target azimuths. Observer scan behavior varied widely, as a function of personal scanning techniques. Most tended to roughly approximate the normal distribution with the mean at center of mass of the targets.

D. CHRONOLOGICAL SEQUENCE OF TARGET DETECTIONS

The vast majority of Army high resolution combat models use the NVEOL search model. That model treats detection of the first target independently from the second, which is treated independently from the next. The model classifies a detection in one of two categories: single target or multiple targets. The multiple targets are handled as one, with mean time detect much shorter than for the single targets [Ref. 4: p. 7]. This chronological ordering of detections of several targets is a complex phenomenon and a primary subject of this analysis. In the next portion of the analysis, we try to determine if it is reasonable to assume, as most combat models do, that detecting one target is independent from detecting the next target.

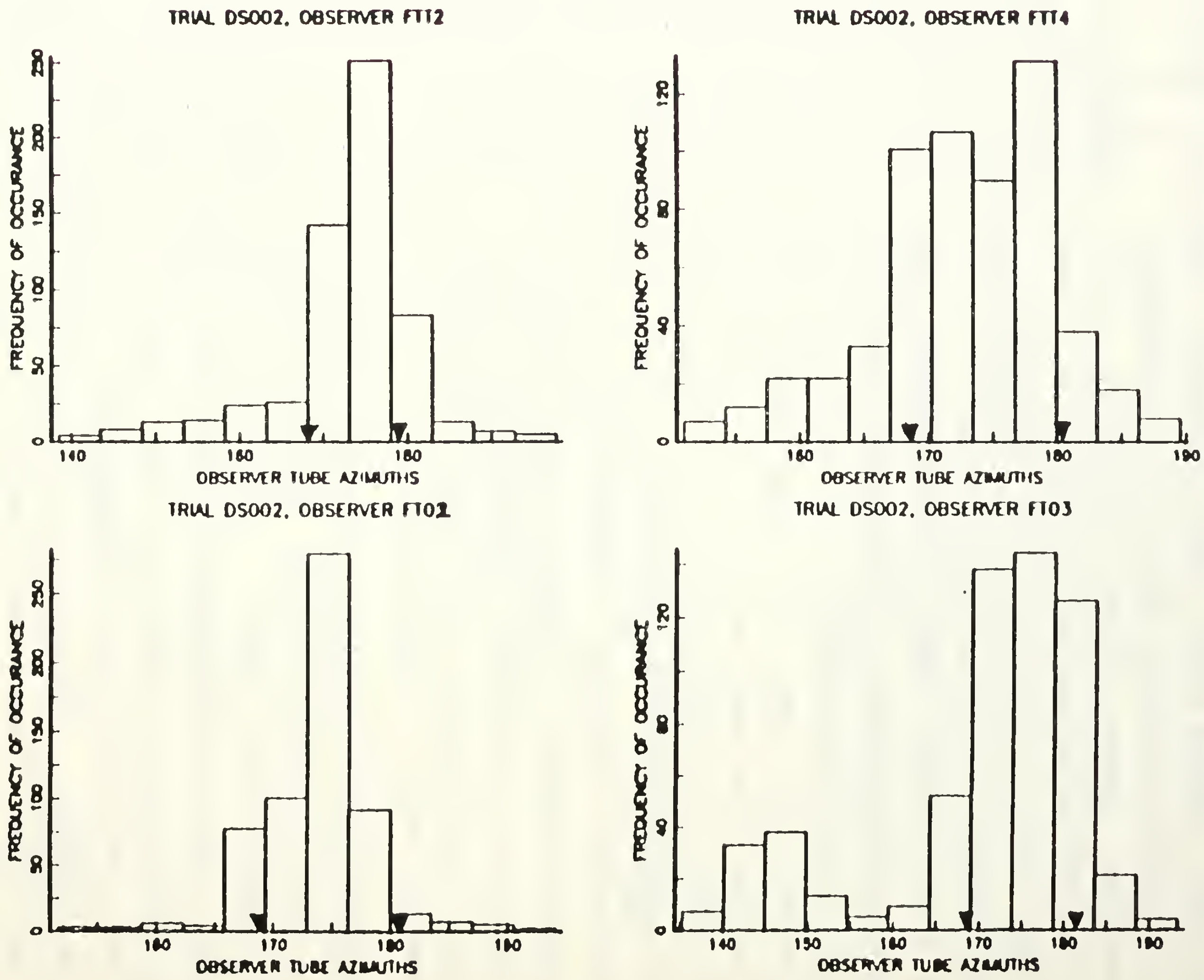


Figure 4.10 Histogram of Observer Scans, Trial DS002

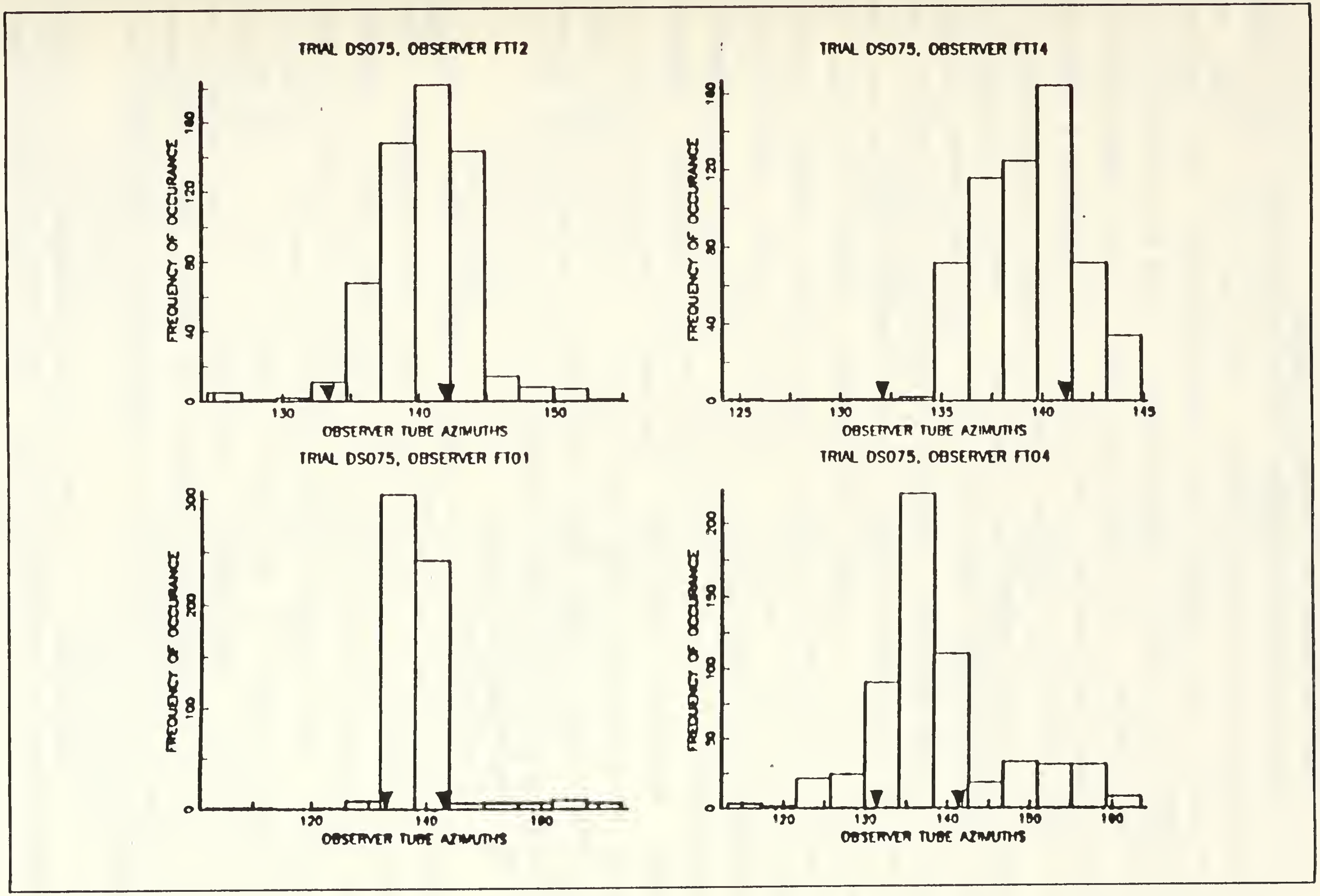


Figure 4.11 Histogram of Observer Scans, Trial DS075

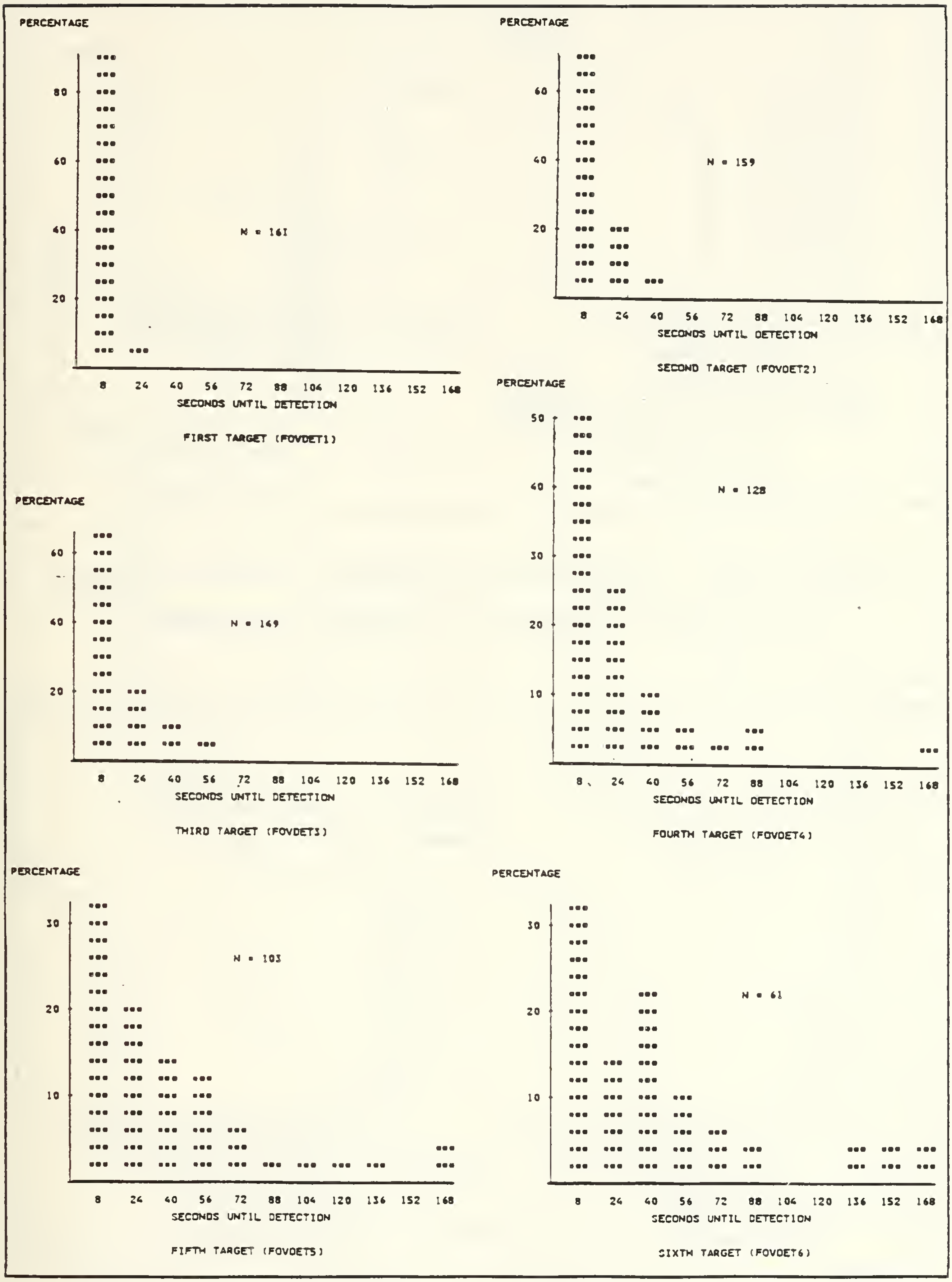
1. Distribution of Times to Detect

The target detections in the data base were sorted chronologically by detect time. Figures 4.12, 4.13, and 4.14 show the detect time distributions for FOVDET, SEARCHDET, and DETDET respectively. Like the geometrically ordered targets, the detection times for all three definitions appear exponential. Because so few observers detected all nine stationary targets, the histograms showing times to detect the ninth target were omitted. Recall 35 percent of the first targets detected were the left-most target, because that was the one the observer's FOV first came across as he scanned right. Also remember the average time required just to reach the assigned search area was 10 seconds. So we would expect to see slightly longer times to detect that first target. The effect can be seen in both SEARCHDET and DETDET distributions. FOVDET does not demonstrate this. In fact, it indicates the opposite, because FOVDET does not count the time spent searching with the sight pointed away from the target. FOVDET times were noticeably shorter for the first target compared to subsequent detections of other targets.

2. Mean Time to Detect

In Figure 4.15,the mean FOVDET times indicate linearity by target sequence, an interesting pattern. The observer scanned the search area back and forth, passing over the harder-to-find targets, detecting the easier ones. Meanwhile, FOV "clocks" accumulated FOV time for all of the undetected targets. As seen in Figure 4.15, the eighth target detected was likely the hardest of the targets to find, and accumulated the longest time within FOV. Compare this linearity to the plots of the means for the other two definitions.

The mean time to detect using SEARCHDET and DETDET methods are shown in Figure 4.16. The first target shows



FIRST TARGET (FOVDET1)

SECOND TARGET (FOVDET2)

THIRD TARGET (FOVDET3)

FOURTH TARGET (FOVDET4)

FIFTH TARGET (FOVDET5)

SIXTH TARGET (FOVDET6)

Figure 4.12a Distribution of Times to Detect Targets Sorted Chronologically - FOVDET

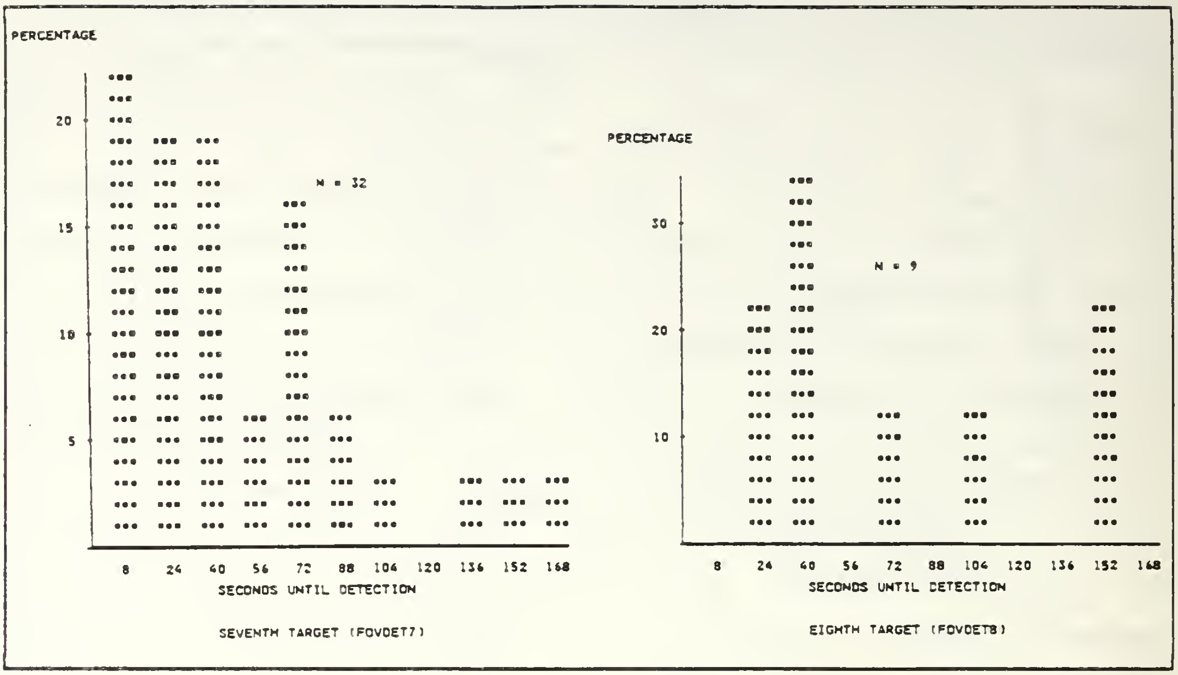


Figure 4.12b Distribution of Times to Detect Targets Sorted Chronologically - FOVDET (Continued)

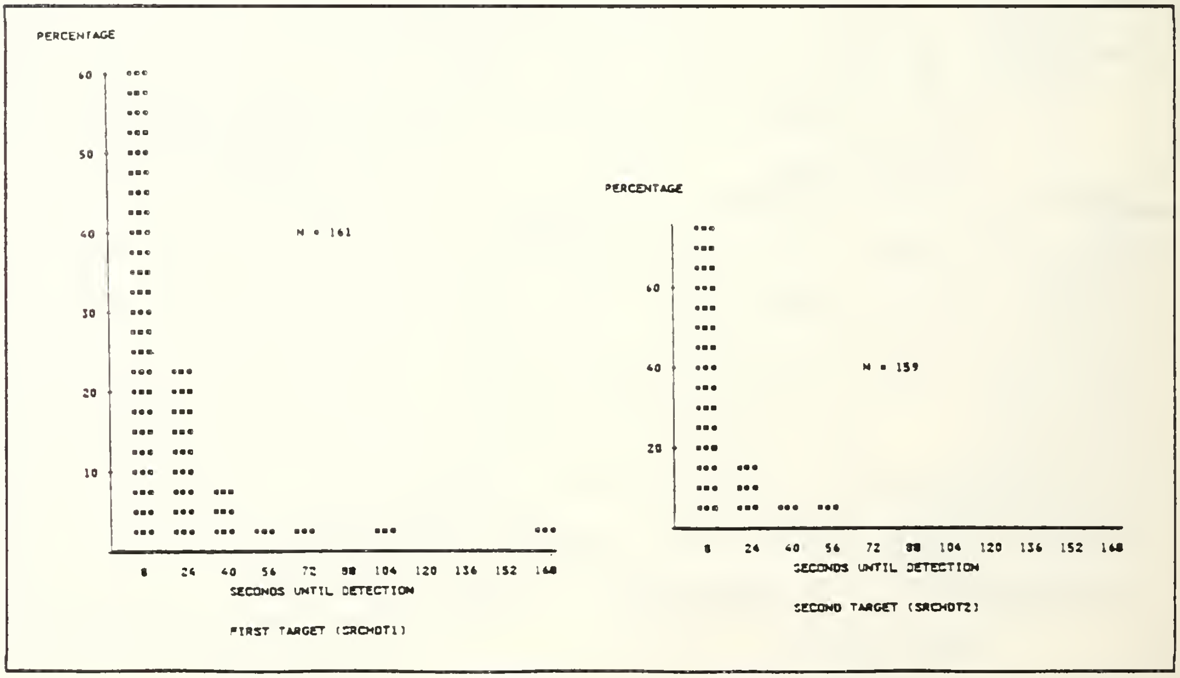


Figure 4.13a Distribution of Times to Detect Targets Sorted Chronologically - SEARCHDET

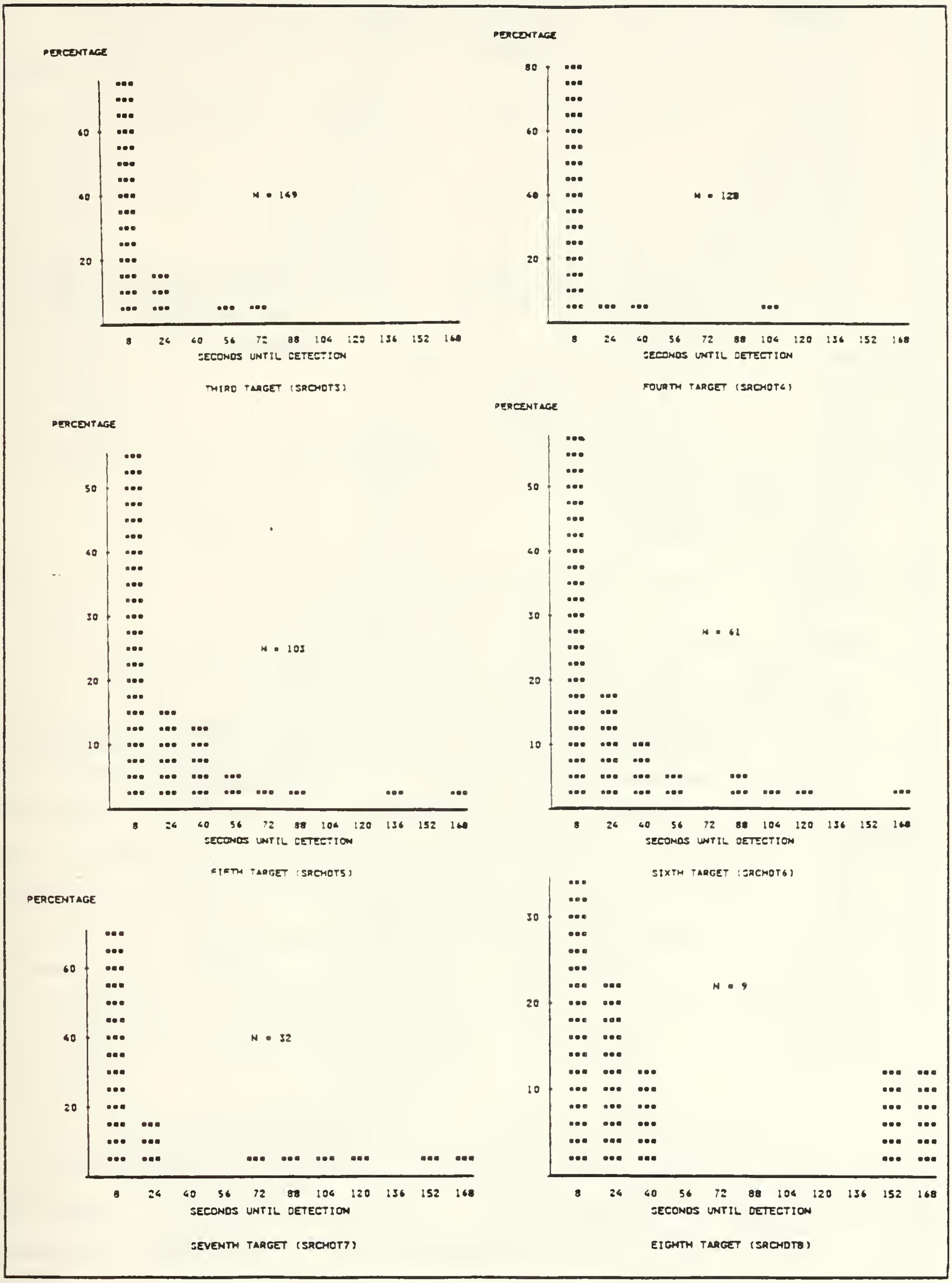


Figure 4.13b Distribution of Times to Detect Targets Sorted Chronologically - SEARCHDET (Continued)

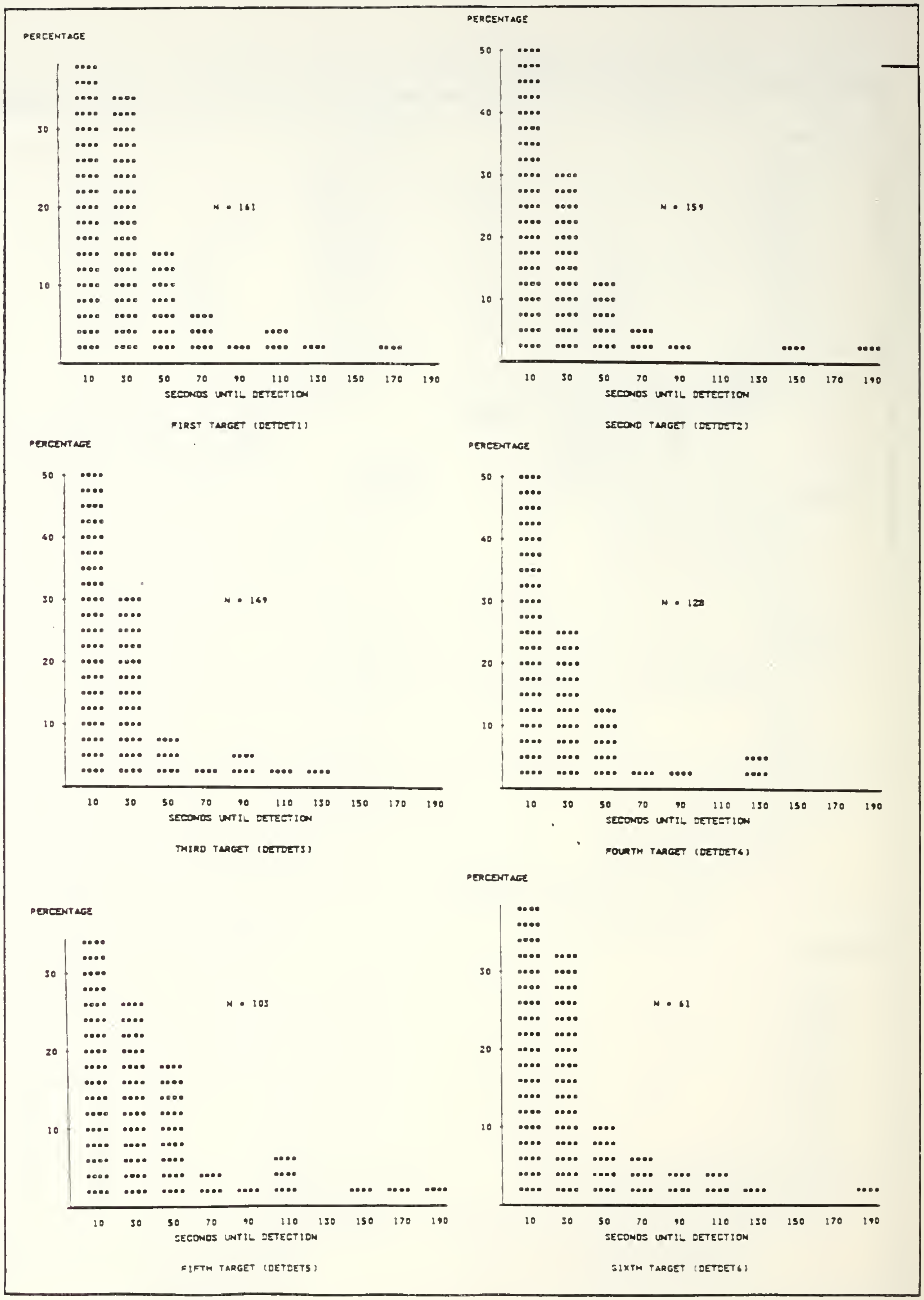


Figure 4.14a Distribution of Times to Detect Targets Sorted Chronologically - DETDET

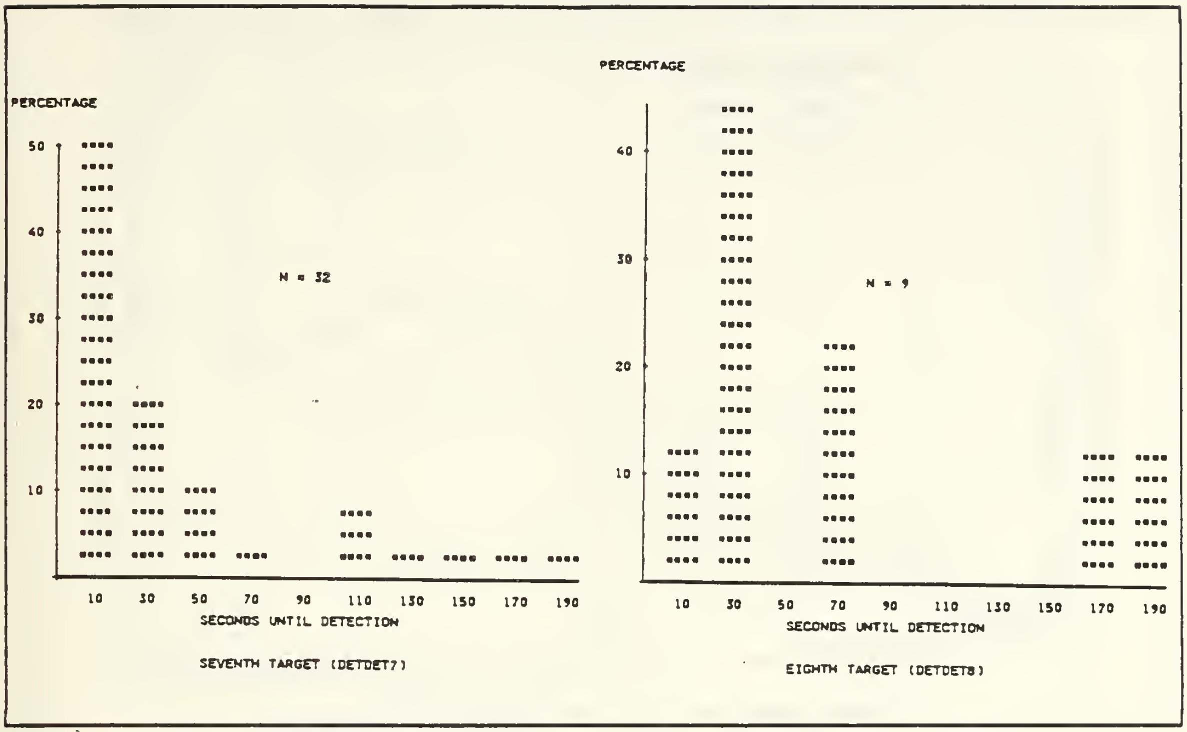


Figure 4.14b Distribution of Times to Detect Targets Sorted Chronologically - DETDET (Continued)

the higher time forced by the pretrial azimuth orientation. The targets were relatively close together in OT azimuth, so after the observer detected the first target, his sight was near in azimuth to the other targets in the area. Thus his time to detect the second target was less. It appears this proximity to the other targets had diminishing affect as the targets got tougher and tougher to detect. Past the first four targets, figure shows that the relationship between mean times to detect and target sequence is decidedly nonlinear.

3. Autocorrelation

Figures 4.15 and 4.16 indicate a likely time relationship, or autocorrelation. Each pairwise combination of times to detection was checked for correlation. The Pearson's product moment correlation coefficient was computed using the formula:

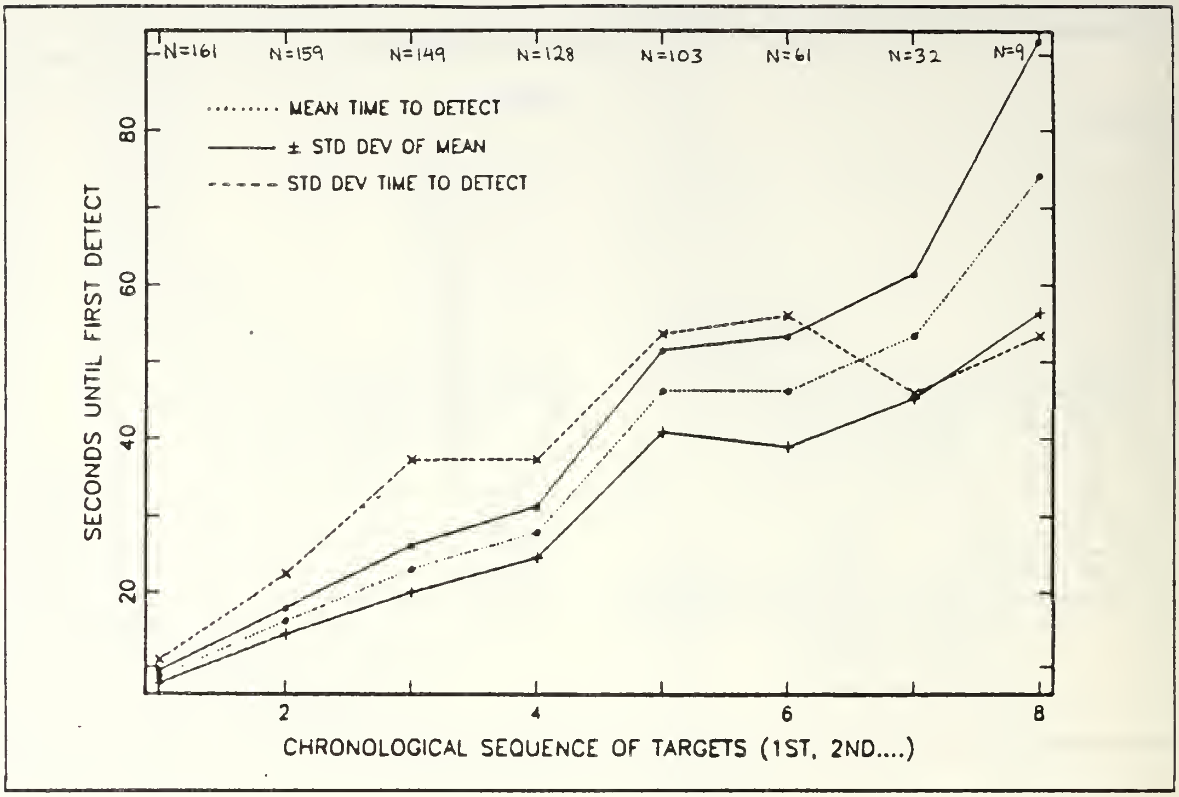


Figure 4.15 Mean Time To Detect Each Target (Chronologically) FOVDET

$$r = \frac{\Sigma(X - \overline{X})(Y - \overline{Y})}{\sqrt{\Sigma(X - \overline{X})^2 \ \Sigma(Y - \overline{Y})^2}}$$

where X and Y are pairwise comparisons of times to detect, and $\overline{X}$ and $\overline{Y}$ are the sample means [Ref. 7: p. 251]. Tables II, III, and IV show the result of these pairwise correlations for FOVDET, SEARCHDET, and DETDET respectively. Also shown are the significance level for a test of Ho: $\rho = 0$, and the sample size N.

Table II shows that for FOVDET, r is generally highest for adjacent pairs, and tends to gradually decline as the separation in sequence is greater. We can see the time dependence between the first detection and the second, and between the second and the third, and so on. Thus,

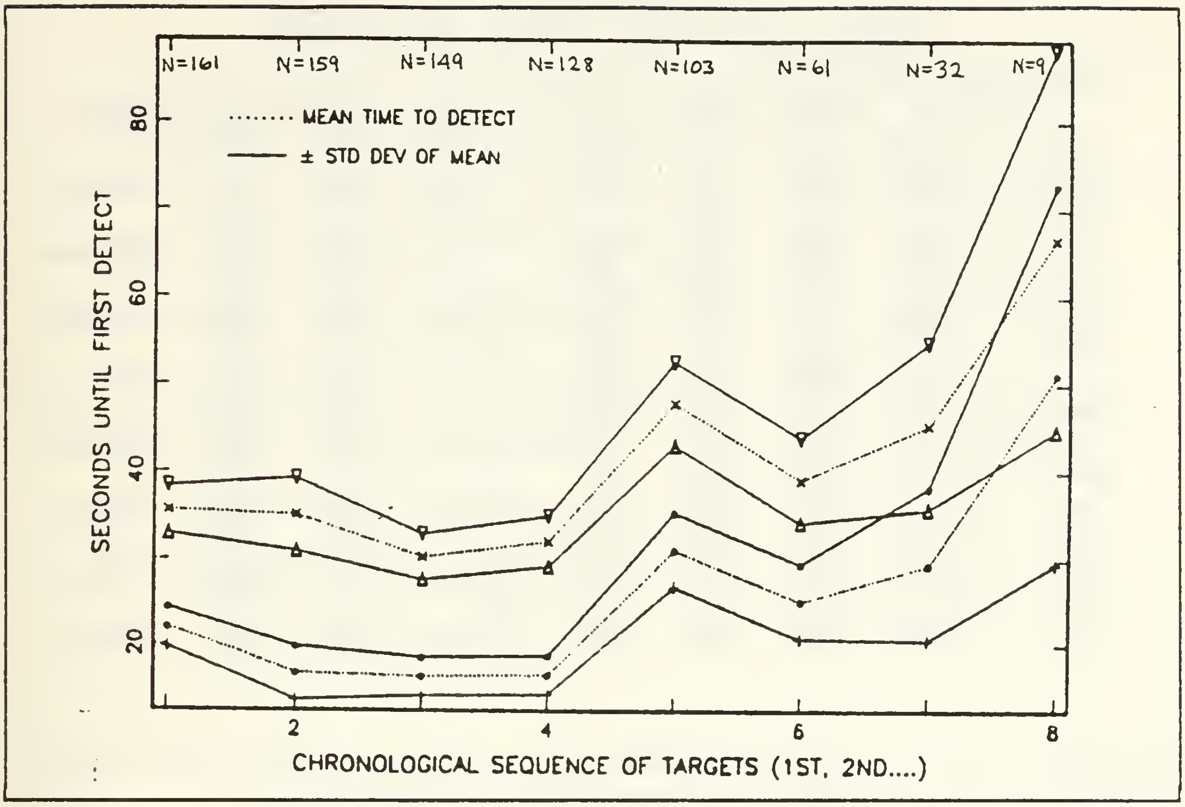


Figure 4.16 Mean Time To Detect Each Target (Chronologically) DETDET and SEARCHDET

there appears to be lag one autocorrelation for FOVDET. A brief look at Tables III and IV indicate SEARCHDET and DETDET do not follow this correlation pattern. The eratic behavior of r for the latter two measures of times to detect leads one to conclude there is little consistent time series correlation with SEARCHDET and DETDET.

E. MODEL FOR FOVDET

A mathematical model was developed, in an attempt to better understand this interesting behavior of mean times in FOV as shown in Figure 4.15, and to understand the observed correlations shown in Table II. Professor Barr and Ross [Ref. 8: pp. 47,48], were of great help in this model. Consider targets in order of detection, and let T_i be the time within FOV until detection of the ith target (FOVDET).

TABLE II

CORRELATION COEFFICIENTS FOR FOVDET

```
CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS
          FOVDET1   FOVDET2   FOVDET3   FOVDET4   FOVDET5   FOVDET6   FOVDET7   FOVDET8

FOVDET1   1.00000   0.73397   0.46404   0.35895   0.43111   0.57442   0.27889   0.57653
           0.0000    0.0001    0.0001    0.0001    0.0001    0.0001    0.1222    0.1042
              161       159       149       128       103        61        32         9

FOVDET2   0.73397   1.00000   0.71663   0.50180   0.49936   0.62690   0.40017   0.28010
           0.0001    0.0000    0.0001    0.0001    0.0001    0.0001    0.0232    0.4654
              159       159       149       128       103        61        32         9

FOVDET3   0.46404   0.71663   1.00000   0.77346   0.67913   0.76595   0.47249   0.39866
           0.0001    0.0001    0.0000    0.0001    0.0001    0.0001    0.0063    0.2879
              149       149       149       128       103        61        32         9

FOVDET4   0.35895   0.50180   0.77346   1.00000   0.79907   0.77537   0.55552   0.41457
           0.0001    0.0001    0.0001    0.0000    0.0001    0.0001    0.0010    0.2672
              128       128       128       128       103        61        32         9

FOVDET5   0.43111   0.49936   0.67913   0.79907   1.00000   0.87815   0.70015   0.10054
           0.0001    0.0001    0.0001    0.0001    0.0000    0.0001    0.0001    0.7969
              103       103       103       103       103        61        32         9

FOVDET6   0.57442   0.62690   0.76595   0.77537   0.87815   1.00000   0.71016   0.32384
           0.0001    0.0001    0.0001    0.0001    0.0001    0.0000    0.0001    0.3953
               61        61        61        61        61        61        32         9

FOVDET7   0.27889   0.40017   0.47249   0.55552   0.70015   0.71016   1.00000   0.40050
           0.1222    0.0232    0.0063    0.0010    0.0001    0.0001    0.0000    0.2855
               32        32        32        32        32        32        32         9

FOVDET8   0.57653   0.28010   0.39866   0.41457   0.10054   0.32384   0.40050   1.00000
           0.1042    0.4654    0.2879    0.2672    0.7969    0.3953    0.2855    0.0000
                9         9         9         9         9         9         9         9
```

TABLE III

CORRELATION COEFFICIENTS FOR SEARCHDET

```
CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS
          SRCHDT1   SRCHDT2   SRCHDT3   SRCHDT4   SRCHDT5   SRCHDT6   SRCHDT7   SRCHDT8

SRCHDT1   1.00000   0.13978   0.10153   0.09045   0.35428   0.02514  -0.08975   0.32246
           0.0000    0.0789    0.2179    0.3099    0.0002    0.8475    0.6252    0.3974
              161       159       149       128       103        61        32         9

SRCHDT2   0.13978   1.00000   0.19671   0.22856   0.23668   0.16985   0.43222  -0.27177
           0.0789    0.0000    0.0162    0.0095    0.0161    0.1906    0.0135    0.4793
              159       159       149       128       103        61        32         9

SRCHDT3   0.10153   0.19671   1.00000   0.31687   0.16523   0.13652   0.20205   0.13642
           0.2179    0.0162    0.0000    0.0003    0.0953    0.2941    0.2674    0.7264
              149       149       149       128       103        61        32         9

SRCHDT4   0.09045   0.22856   0.31687   1.00000   0.17132   0.16349  -0.16186  -0.41049
           0.3099    0.0095    0.0003    0.0000    0.0836    0.2080    0.3761    0.2725
              128       128       128       128       103        61        32         9

SRCHDT5   0.35428   0.23668   0.16523   0.17132   1.00000  -0.04241   0.23480  -0.20124
           0.0002    0.0161    0.0953    0.0836    0.0000    0.7456    0.1958    0.6036
              103       103       103       103       103        61        32         9

SRCHDT6   0.02514   0.16985   0.13652   0.16349  -0.04241   1.00000   0.23946  -0.33701
           0.8475    0.1906    0.2941    0.2080    0.7456    0.0000    0.1868    0.3751
               61        61        61        61        61        61        32         9

SRCHDT7  -0.08975   0.43222   0.20205  -0.16186   0.23480   0.23946   1.00000  -0.28873
           0.6252    0.0135    0.2674    0.3761    0.1958    0.1868    0.0000    0.4511
               32        32        32        32        32        32        32         9

SRCHDT8   0.32246  -0.27177   0.13642  -0.41049  -0.20124  -0.33701  -0.28873   1.00000
           0.3974    0.4793    0.7264    0.2725    0.6036    0.3751    0.4511    0.0000
                9         9         9         9         9         9         9         9
```

We will split T_i into two parts. Let U_i be the time in FOV that target i accumulated prior to the last target (i-1) detection. Let V_i be the time in FOV accumulated by target

TABLE IV
CORRELATION COEFFICIENTS FOR DETDET

```
CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS
             DETDET1   DETDET2   DETDET3   DETDET4   DETDET5   DETDET6   DETDET7   DETDET8

DETDET1      1.00000   0.26713   0.22093   0.11275   0.29122   0.03837  -0.02268   0.62020
              0.0000    0.0007    0.0068    0.2051    0.0028    0.7691    0.9019    0.0748
                 161       159       149       128       103        61        32         9

DETDET2      0.26713   1.00000   0.26499   0.27132   0.17458   0.05585   0.27645  -0.05327
              0.0007    0.0000    0.0011    0.0019    0.0778    0.6690    0.1256    0.8917
                 159       159       149       128       103        61        32         9

DETDET3      0.22093   0.26499   1.00000   0.24875   0.26432   0.25086   0.12404   0.08058
              0.0068    0.0011    0.0000    0.0046    0.0070    0.0512    0.4988    0.8367
                 149       149       149       128       103        61        32         9

DETDET4      0.11275   0.27132   0.24875   1.00000   0.19479   0.06535  -0.02111  -0.18663
              0.2051    0.0019    0.0046    0.0000    0.0486    0.6168    0.9087    0.6307
                 128       128       128       128       103        61        32         9

DETDET5      0.29122   0.17458   0.26432   0.19479   1.00000   0.10821   0.25241  -0.28432
              0.0028    0.0778    0.0070    0.0486    0.0000    0.4065    0.1634    0.4584
                 103       103       103       103       103        61        32         9

DETDET6      0.03837   0.05585   0.25086   0.06535   0.10821   1.00000   0.19402  -0.29084
              0.7691    0.6690    0.0512    0.6168    0.4065    0.0000    0.2873    0.4477
                  61        61        61        61        61        61        32         9

DETDET7     -0.02268   0.27645   0.12404  -0.02111   0.25241   0.19402   1.00000  -0.34845
              0.9019    0.1256    0.4988    0.9087    0.1634    0.2873    0.0000    0.3581
                  32        32        32        32        32        32        32         9

DETDET8      0.62020  -0.05327   0.08058  -0.18663  -0.28432  -0.29084  -0.34845   1.00000
              0.0748    0.8917    0.8367    0.6307    0.4584    0.4477    0.3581    0.0000
                   9         9         9         9         9         9         9         9
```

i since the last detection. Finally, let t_i be the observed outcome on T_i, that is the accumulated time in FOV until target i is detected. Thus, we have

$$T_i = U_i + V_i . \qquad \text{(eqn 4.1)}$$

By definition, $U_1 = 0$ and so $T_1 = V_1$. For this simple model, assume that $V_i \sim \exp(\lambda')$ and $U_i \sim \exp(\lambda / \sum_{j=1}^{i-1} t_j)$, given $\sum_{j=1}^{i-1} t_j$ seconds were utilized in detecting the first i-1 targets (ie. $T_1 = t_1, T_2 = t_2, \ldots, T_{i-1} = t_{i-1}$). Also assume the V_i s are independent, and V_i and U_i are independent of each other for all i. For the sake of ease of reading, we will let $a = 1/\lambda'$, and $b = 1/\lambda$. Now

$$\begin{aligned} E[T_1] &= E[V_1] = a \\ E[T_2] &= E_{T_1}[E(T_2 \mid T_1)] \\ &= E_{T_1}[T_1 b + a] \\ &= [E(V_1)b] + a. \end{aligned}$$

Given $T_1 = t_1$ and $T_2 = t_2$, then $T_3 = U_3 + V_3$, where $U_3 \sim \exp|(1/(t_1 + t_2)b|$, $V_3 \sim \exp(1/a)$, and U_3 and V_3

are independent. Now

$$E[T \mid V = t , V = t] = b(t + t) + a$$

$$E[T] = E \mid b(T + T) + a \mid$$

$$= \mid E(V) + E(V) \mid b + a.$$

In general, for $i>1$,

$$E[T] = [E(V) + E(V) + \ldots + E(V)]b + a. \qquad \text{(eqn 4.2)}$$

If k is the target sequence number, V ,V ,...V have common mean a. It follows that

$$E[V] = (k-1)ab + a = k(ab) + a(1-b), \qquad \text{(eqn 4.3)}$$

a linear function in k.

To give a rough idea of how the model fits the data, a least squares line was fit to the mean times to detect in Figure 4.15. The resulting equation was $y = 7.63k + .86$, with an r value of .98. Substituting back into equation 4.3, we get $a = 8.49$ and $b = .90$. $E[U] = b\ t$, and t is estimated to be 9 from Figure 4.15. Thus $E[U] = 8.1$, $E[V] = a = 8.49$, and so $E[T] = 16.6$. This is consistent with the estimate of the mean for the second target shown in Figure 4.15.

Now we calculate the covariance of the time in FOV of the first two targets detected, T , and T . By definition,

$$\mathrm{Cov}[T ,T] = E[T\ T]-E[T]E[T]. \qquad \text{(eqn 4.4)}$$

Solving the two parts separately, we have

$$E[T\ T] = E\ [E(T\ T \mid T = t)] = E\ \mid t\ E(T \mid t) \mid$$

$$= E\ \mid T\ (T\ b+a) \mid = bE[T^2] + aE[T]$$

$$= b(2a^2) + a^2 = a^2(2b+1), \text{ and}$$

$$E[T]E[T] = a \mid a(b+1) \mid = a^2(b+1).$$

The covariance of T and T is then

$$\mathrm{Cov}[T\ ,T\ ] = a^2(2b+1) - a^2(b+1) = a^2(b) > 0 \qquad \text{(eqn 4.5)}$$

In a similar way, Var(T) and Var(T) are computed to be a^2 and $a^2(2b^2+b+1)$, respectively. Thus

$$[T\ ,T\ ] = (a^2b)/(a\mathrm{Var}[T\ ]) = (a^2b)/\ a|a\ 2b^2+b+1|$$

$$[T\ ,T\ ] = b/\ \ 2b^2+b+1 \qquad \text{(eqn 4.6)}$$

which interestingly, does not depend on a. For our data with b = .90, [T ,T] = .48. In Table II however, the correlation between the first two targets is .73. This indicates this simple model gives roughly approximate results, but further model refinement might prove more acurate. It is interesting to note that equation 4.6 assymptotes at 1/ 2 = .707 for high values of b.

Even though this is a very simple model, it appears to explain some major features of time in FOV we have observed. It would be possible to expand this simple model to accomodate different parameters for the distributions of the V , to model varying difficulties of detecting the various targets. The assumption of exponential distributions for V s could also be examined.

V. CONCLUSIONS AND RECOMMENDATIONS

In this analysis, we studied multiple target detections in some uncommon ways. We computed the time in FOV until detection and we compared this with the two widely used definitions of time to detection--interdetection times, and search time to detection. We studied patterns in the geometric ordering of targets. We looked at scan behavior and the observer's FOV related to target locations. Finally, we saw the effects of chronological ordering of targets, and how time series correlation affects the method FOVDET.

A. GEOMETRIC PERSPECTIVE

Studying detections from the observer-target geometry perspective gave an interesting view of the data. The decision to orient observer sights to the left prior to each trial forced a significant bias into the detection data. This was most noticeable when looking at the distribution of first detections by relative target position. In 35 percent of the observer/trials, the first target detected was the left-most target, and 75 percent of the first detections were in the left four targets. Relative target location was not a controlled factor in the test, so uneven distribution of target factors was very likely. In the only target factor checked in this analysis--target type--it was found quite unevenly distributed. The impact of this bias on test results is probably not severe in this study because we looked only at pooled data. It is recommended that an extension of this analysis be made to determine impact of the bias on the full factor studies done in the past on the Thermal Pinpoint Test.

It is recommended that combat development tests of this type use an alternative method of preventing pretrial viewing of the target area. If no suitable method is feasible, then relative target location should probably be made a controlled test design factor.

Observer scan data showed some interesting results. It displayed great differences in human observer scan behavior. It also indicated the effect of the Test's initial azimuth orientation. To provide greater insight into detections of multiple targets, further study is recommended into the effectiveness of various observer scan rates and search techniques.

B. TIME WITHIN FIELD OF VIEW

In this analysis the FOVDET computation was a mixed "success". To compute the time within FOV requires a substantial effort and uses large amounts of computer CPU time and storage space. It is estimated that over 80 percent of the time spent preparing this analysis was in writing the five SAS programs to compute the FOVDET values. With those programs listed in the appendixes, this effort should not have to be repeated by those wishing to use this measure in the future. The somewhat severe data requirements to compute FOVDET forced us to delete over two thirds of the Thermal Pinpoint data. A test designed with these requirements in mind, of course, should not have this problem.

While FOVDET has some disadvantages, it has compensating advantages. Any tool which enables one to further understand detection is of benefit. Over a sequence of targets, FOVDET gave an approximately linear mean time to detect, and resulted in consistent correlation behavior. This consistent and simple behavior was not exhibited by SEARCHDET or DETDET. A mathematical model was developed to help explain the behavior of mean time in FOV for detection of successive targets. It also models the autocorrelation involved. An extension of this model is recommended.

The time within FOV definition of detect time offers a fresh area for exploration into the phenomenon of multiple target detections. It is recommended that further study be done using the FOVDET definition--especially toward application to combat modelling.

APPENDIX A

AZIMTEST SAS PROGRAM

```
//AZIMTEST  JDB (I477,9999),'DUBOIS',CLASS=C
//*MAIN SYSTEM=SY2,CARDS=(200),LINES=(I00)
//*
//*  THIS PROGRAM CREATES A SAS DATA SET MSS.SI477.AZIMTEST FROM TPDAZ.
//*  IT READS THE OBSERVER AZIMUTH RECDRDS AND ASSIGNS VARIABLE NAMES
//*  FOR USE IN THE PROGRAM TIMINFOV.
//*
// EXEC SAS V5,REGION=II20K
//WORK DD SPACE=(CYL,(B,B))
//DATAOUT DD UNIT=3330V,MSVGP=PUB4B,DISP=(OLD,KEEP),
//         DSNAME=MSS.SI477.AZIMTEST
//DATAINI DD DISP=SHR,DSNAME=MSS.FI742.TPDAZ
//SYSIN DD *
OPTIONS LINESIZE = I32  PAGESIZE=60;
DATA DNE:
  INFILE DATAINI;
  ARRAY AZ (I) AZI-AZ600;
  INPUT FLAGI $ I-5  FLAG2 $ 7-I0 @;
  IF (SUBSTR(FLAGI,I,I) NE 'D') OR (FLAG2 = '    ') THEN DELETE;
  ELSE DO:
    INPUT IDTRIAL $ I-5  IDOBS $ 7-I0  AZI-AZI0;
    I=10:
    DD B=0 TD 52;
      DO C=I TO II:
        I=I0 + B*II + C:
        INPUT AZ @:
      END:
      INPUT;
    END:
    INPUT #55 AZ594-AZ600:
  END;
*****************************************;
*IF SUBSTR(IDTRIAL,3,I) NE '0' THEN DELETE;
****************************************;
DATA TWO:
  RETAIN IDTRIAL IDOBS AZI-AZ600:
  SET ONE:
  ARRAY AZ (I) AZ1-AZ600;
********** AZIMUTH CALIBRATION CORRECTION ***********;
  DO I = I TO 600:
    IF AZ=0 THEN AZ=.:
    IF IDTRIAL='DS001' AND IDOBS='FTT2' THEN AZ=AZ-I;
    IF IDTRIAL='DS003' AND IDOBS='FT03' THEN AZ=AZ+I.5:
    IF IDTRIAL='DS030' AND IDOBS='FT03' THEN AZ=AZ+I;
    IF IDTRIAL='DS04B' AND IDOBS='FT01' THEN AZ=AZ-.5:
    IF IDTRIAL='DS050' AND IDOBS='FT0I' THEN AZ=AZ-.5:
    IF IDTRIAL='DS060' AND IDOBS='FT03' THEN AZ=AZ-2;
    IF IDTRIAL='DS06I' AND IDOBS='FT03' THEN AZ=AZ+I;
    IF IDTRIAL='DSI77' AND IDOBS='FTT3' THEN AZ=AZ-.5;
    IF IDTRIAL='DSI7B' AND IDDBS='FTTI' THEN AZ=AZ+.5:
    IF IDTRIAL='DSI79' AND IDDBS='FTT3' THEN AZ=AZ-.5:
    IF IDTRIAL='DSI94' AND IDDBS='FT03' THEN AZ=AZ-1:
    IF IDTRIAL='DSI96' AND IDDBS='FT03' THEN AZ=AZ-I.5:
    IF IDTRIAL='DS254' AND IDOBS='FT02' THEN AZ=AZ-.3:
    IF IDTRIAL='DS255' AND IDOBS='FTTI' THEN AZ=AZ-.5:
    IF IDTRIAL='DS267' AND IDOBS='FT03' THEN AZ=AZ+.5;
    IF IDTRIAL='DS276' AND IDOBS='FT03' THEN AZ=AZ+1:
************ END CORRECTION **************************;
```

```
    END;
PROC SORT;
  BY IDTRIAL IDOBS;
******************************************;
DATA DATAOUT.AZIMTEST;
  SET TWO;
*PROC PRINT;
*  VAR IDTRIAL IDOBS AZ1-AZ600;
*  TITLE 'AZIMTEST LISTING';
*  TITLE2 'AZ1-AZ600 FOR TPDS TRIALS';
******************************************;
*DATA _NULL_;
* SET THREE;
* FILE PUNCH;
* PUT IDTRIAL IDOBS AZ1-AZ600;
*RUN;
/*
//
```

APPENDIX B

OTAZ SAS PROGRAM

```
//OTAZ  JOB (1477,9999),'DUBOIS',CLASS*B
//*MAIN SYSTEM=SY2,CARDS=(100)
//*
//*  TMIS PROGRAM COMPUTES TME ACTUAL OBSERVER-TO-TARGET AZIMUTMS AND
//*  RANGES FROM EACM OF TME FOUR OBSERVERS TO EACH OF TME TEN TARGETS.
//*  TME INFORMATION COMES FROM THE HEADER RECORDS IN MSS.F1742.TPDS.
//*
//  EXEC SAS,REGION=1600K
//WORK DD SPACE=(CYL,(8,B))
//DATAIN DD DISP=SHR,DSNAME=MSS.F1742.TPDS
//DATAOUT DD DISP=(OLD,KEEP),DSNAME=MSS.S1477.OTAZ
//SYSIN DD *
OPTIONS LINESIZE =132   PAGESIZE=60;
********************************************;
DATA ONE:
  INFILE DATAIN;
********************************************;
  INPUT RECTYPE $ 1 TRLFLAG $ 2-6 @;
  IF RECTYPE NE 'M' TMEN DELETE;
* IF TRLFLAG NE 'DS021' AND TRLFLAG NE 'DS02B' TMEN DELETE:
  IF RECTYPE = 'M' THEN DO:
    INPUT #1  IDTRIAL $ 2-6
             IDOBS1 $ 21-24  XOBS1 3B-42  YOBS1 43-47
             IDOBS2 $ 4B-51  XOBS2 65-69  YOBS2 70-74
             IDOBS3 $ 75-7B
         #2  XOBS3 14-1B  YOBS3 19-23
             IDOBS4 $ 24-27  XOBS4 41-45  YOBS4 46-50
         #4  LIGMTLVL 11-16
             IDTGTI $ 17-20  XTGT1 42-46  YTGT1 47-51
             TMPCNT1 21-26  VISCNT1 27-32  CONDIT1 $ 33-35
             IDTGT2 $ 52-55
             TMPCNT2 56-61  VISCNT2 62-67  CONDIT2 $ 6B-70
         #5  XTGT2 1-5   YTGT2 6-10
             IDTGT3 $ 11-14  XTGT3 36-40  YTGT3 41-45
             TMPCNT3 15-20  VISCNT3 21-26  CONDIT3 $ 27-29
             TMPCNT4 50-55  VISCNT4 56-61  CONDIT4 $ 62-64
             IDTGT4 $ 46-49  XTGT4 71-75  YTGT4 76-B0
         #6  TMPCNT5 5-10   VISCNT5 11-16  CONDIT5 $ 17-19
             IDTGT5 $ 1-4   XTGT5 26-30  YTGT5 31-35
             TMPCNT6 40-45  VISCNT6 46-51  CONDIT6 $ 52-54
             IDTGT6 $ 36-39  XTGT6 61-65  YTGT6 66-70
             IDTGT7 $ 71-74
             TMPCNT7 75-80
         #7  VISCNT7 1-6    CONDIT7 $ 7-9
             TMPCNTB 30-35  VISCNTB 36-41  CONDITB $ 42-44
             TMPCNT9 65-70  VISCNT9 71-76  CONDIT9 $ 77-79
             XTGT7 16-20  YTGT7 21-25
             IDTGTB $ 26-29  XTGTB 51-55  YTGTB 56-60
             IDTGT9 $ 61-64
         #B  XTGT9 7-11  YTGT9 12-16
             TMPCNT10 21-26  VISCNT10 27-32  CONDIT10 $ 33-35
             IDTGT10 $ 17-20  XTGT10 42-46  YTGT10 47-51
         #9;
    END:
  ARRAY BOTAZ (H) BOTAZ1-BOTAZ40:
  ARRAY RNGE (M) RNGE1-RNGE40:
  ARRAY IDOBS (I) $ IDOBS1-IDOBS4;
  ARRAY YOBS (J) YOBS1-YOBS4:
```

```
 ARRAY XOBS (J) XOBS1-XOBS4;
 ARRAY IDTGT (K) $ IDTGT1-IDTGT10;
 ARRAY YTGT (L) YTGT1-YTGT10;
 ARRAY XTGT (L) XTGT1-XTGT10;
********* FOR EACH TRIAL *******************;
  DO J = 1 TO 4;
   DO L = 1 TO 10;
    H = (J-1)*10 + L;
    IF (XOBS = 99999) OR (YOBS = 99999) OR (XTGT = 99999) OR
      (YTGT = 99999) THEN DO:
     BOTAZ = .;  RNGE=.;
      GO TO Q;
    END;
    IF (XOBS = 88888) OR (YOBS = 88888) OR (XTGT = 88888) OR
      (YTGT = 88888) THEN DO:
     BOTAZ = .;  RNGE =.;
      GO TO Q;
    END:
    A = (YTGT - YOBS)/(XTGT - XOBS);
    IF XTGT GE XOBS THEN BOTAZ=ROUND(90-(ATAN(A)*180/3.141593),.01);
    IF XTGT LT XOBS THEN BOTAZ=ROUND(270-(ATAN(A)*180/3.141593),.01);
    RNGE = ROUND(SQRT((XOBS-XTGT)**2 + (YOBS-YTGT)**2));
 Q:  END;
  END;
**********************************;
DATA TWO;
 SET ONE;
 ARRAY BOTAZ (H) BOTAZ1-BOTAZ40;
 ARRAY RNGE (H) RNGE1-RNGE40;
 ARRAY OTAZ (M) OTAZ1-OTAZ10;
 ARRAY RANGE (M) RANGE1-RANGE10;
 IDOBS=IDOBS1;
 DO H=1 TO 10;
  M=H;
  OTAZ=BOTAZ;
  RANGE=RNGE;
  END;
**********************************;
DATA THREE;
 SET ONE;
 ARRAY BOTAZ (H) BOTAZ1-BOTAZ40;
 ARRAY RNGE (H) RNGE1-RNGE40;
 ARRAY OTAZ (M) OTAZ1-OTAZ10;
 ARRAY RANGE (M) RANGE1-RANGE10;
 IDOBS=IDOBS2;
 DO H=11 TO 20;
  M=H-10;
  OTAZ=BOTAZ;
  RANGE=RNGE;
  END;
**********************************;
DATA FOUR;
 SET ONE;
 ARRAY BOTAZ (H) BOTAZ1-BOTAZ40;
 ARRAY RNGE (H) RNGE1-RNGE40;
 ARRAY OTAZ (M) OTAZ1-OTAZ10;
 ARRAY RANGE (M) RANGE1-RANGE10;
 IDOBS=IDOBS3;
```

```
                                                        PAGE 3

  DD H=21 TD 30;
    M=H-20;
    DTAZ=BDTAZ;
    RANGE=RNGE;
    END;
*********************************;
DATA FIVE;
  SET DNE;
  ARRAY BDTAZ (H) BDTAZ1-BDTAZ40;
  ARRAY RNGE (H) RNGEI-RNGE40;
  ARRAY DTAZ (M) DTAZ1-DTAZ10;
  ARRAY RANGE (M) RANGE1-RANGE10;
  IDDBS=IDDBS4;
  DD H=31 TD 40;
    M=H-30;
    DTAZ=BDTAZ;
    RANGE=RNGE;
    END;
*********************************;
DATA SIX;
  SET TWD THREE FDUR FIVE;
  DRDP  BDTAZ1-BDTAZ40  RNGE1-RNGE40  XDBS1-XDBS4  YDBSI-YDBS4
        XTGT1-XTGTI0  YTGT1-YTGTI0;
  ARRAY VISCNT (I) VISCNT1-VISCNT10;
  ARRAY TMPCNT (I) TMPCNTI-TMPCNT10;
  IF LIGHTLVL=B.BBBB THEN LIGHTLVL=.;
  DD I=1 TD 10;
    IF VISCNT=999.99 THEN VISCNT=.;
    IF TMPCNT=999.99 THEN TMPCNT=.;
    END;
************************************************************;
********** SDRT VARIABLES BY DTAZ *************************;
  CHNGFLAG=1;
  DD WHILE (CHNGFLAG=1);
    CHNGFLAG=0;
    IF (DTAZ1 GT DTAZ2) THEN DD;
      DTAZ1A=DTAZ1;      DTAZ1=DTAZ2;      DTAZ2=DTAZ1A;
      IDTGT1A=IDTGT1;    IDTGT1=IDTGT2;    IDTGT2=IDTGTIA;
      RANGEIA=RANGEI;    RANGEI=RANGE2;    RANGE2=RANGEIA;
      TMPCNTIA=TMPCNT1;  TMPCNTI=TMPCNT2;  TMPCNT2=TMPCNTIA;
      VISCNT1A=VISCNT1;  VISCNT1=VISCNT2;  VISCNT2=VISCNT1A;
      CDNDIT1A=CDNDIT1;  CDNDIT1=CDNDIT2;  CDNDIT2=CDNDIT1A;
      CHNGFLAG=1;  END;
    IF (DTAZ2 GT DTAZ3) THEN DD;
      DTAZ2A=DTAZ2;      DTAZ2=DTAZ3;      DTAZ3=DTAZ2A;
      IDTGT2A=IDTGT2;    IDTGT2=IDTGT3;    IDTGT3=IDTGT2A;
      RANGE2A=RANGE2;    RANGE2=RANGE3;    RANGE3=RANGE2A;
      TMPCNT2A=TMPCNT2;  TMPCNT2=TMPCNT3;  TMPCNT3=TMPCNT2A;
      VISCNT2A=VISCNT2;  VISCNT2=VISCNT3;  VISCNT3=VISCNT2A;
      CONDIT2A=CDNDIT2;  CDNDIT2=CDNDIT3;  CDNDIT3=CONDIT2A;
      CHNGFLAG=1:  END;
    IF (DTAZ3 GT DTAZ4) THEN DD;
      DTAZ3A=DTAZ3;      DTAZ3=DTAZ4;      DTAZ4=DTAZ3A;
      IDTGT3A=IDTGT3;    IDTGT3=IDTGT4;    IDTGT4=IDTGT3A;
      RANGE3A=RANGE3;    RANGE3=RANGE4;    RANGE4=RANGE3A;
      TMPCNT3A=TMPCNT3;  TMPCNT3=TMPCNT4;  TMPCNT4=TMPCNT3A;
      VISCNT3A=VISCNT3;  VISCNT3=VISCNT4;  VISCNT4=VISCNT3A;
      CDNDIT3A=CDNDIT3;  CDNDIT3=CDNDIT4;  CCNDIT4=CDNDIT3A;
      CHNGFLAG=I;  END;
    IF (OTAZ4 GT OTAZ5) THEN DD;
      OTAZ4A=OTAZ4;        OTAZ4=OTAZ5;        OTAZ5=OTAZ4A;
      IDTGT4A=IDTGT4;      IDTGT4=IDTGT5;      IDTGT5=IDTGT4A;
      RANGE4A=RANGE4;      RANGE4=RANGE5;      RANGE5=RANGE4A;
      TMPCNT4A=TMPCNT4;    TMPCNT4=TMPCNT5;    TMPCNT5=TMPCNT4A;
      VISCNT4A=VISCNT4;    VISCNT4=VISCNT5;    VISCNT5=VISCNT4A;
      CDNDIT4A=CONDIT4;    CONDIT4=CONDIT5;    CONDIT5=CONDIT4A;
      CHNGFLAG=I;  END;
    IF (OTAZ5 GT OTAZ6) THEN DO;
      OTAZ5A=OTAZ5;        OTAZ5=OTAZ6;        OTAZ6=QTAZ5A;
      IDTGT5A=IDTGT5;      IDTGT5=IDTGT6;      IDTGT6=IDTGT5A;
      RANGE5A=RANGE5;      RANGE5=RANGE6;      RANGE6=RANGE5A;
      TMPCNT5A=TMPCNT5;    TMPCNT5=TMPCNT6;    TMPCNT6=TMPCNT5A;
      VISCNT5A=VISCNT5;    VISCNT5=VISCNT6;    VISCNT6=VISCNT5A;
      CONDIT5A=CONDIT5;    CONDIT5=CONDIT6;    CONDIT6=CDNDIT5A;
      CHNGFLAG=I;  END;
    IF (OTAZ6 GT OTAZ7) THEN DO;
      DTAZ6A=DTAZ6;        OTAZ6=OTAZ7;        OTAZ7=OTAZ6A;
      IDTGT6A=IDTGT6;      IDTGT6=IDTGT7;      IDTGT7=IDTGT6A;
      RANGE6A=RANGE6;      RANGE6=RANGE7;      RANGE7=RANGE6A;
      TMPCNT6A=TMPCNT6;    TMPCNT6=TMPCNT7;    TMPCNT7=TMPCNT6A;
      VISCNT6A=VISCNT6;    VISCNT6=VISCNT7;    VISCNT7=VISCNT6A;
      CONDIT6A=CONDIT6;    CONDIT6=CONDIT7;    CONDIT7=CONDIT6A;
      CHNGFLAG=I;  END;
    IF (OTAZ7 GT OTAZ8) THEN DO;
      OTAZ7A=OTAZ7;        OTAZ7=OTAZ8;        OTAZ8=OTAZ7A;
      IDTGT7A=IDTGT7;      IDTGT7=IDTGT8;      IDTGT8=IDTGT7A;
      RANGE7A=RANGE7;      RANGE7=RANGE8;      RANGE8=RANGE7A;
      TMPCNT7A=TMPCNT7;    TMPCNT7=TMPCNT8;    TMPCNT8=TMPCNT7A;
      VISCNT7A=VISCNT7;    VISCNT7=VISCNT8;    VISCNT8=VISCNT7A;
      CONDIT7A=CONOIT7;    CONOIT7=CONOIT8;    CONOIT8=CONDIT7A;
      CHNGFLAG=I;  END;
    IF (OTAZ8 GT OTAZ9) THEN DO;
      OTAZ8A=OTAZ8;        OTAZ8=OTAZ9;        OTAZ9=OTAZ8A;
      IOTGT8A=IDTGT8;      IDTGT8=IDTGT9;      IDTGT9=IDTGT8A;
      RANGE8A=RANGE8;      RANGE8=RANGE9;      RANGE9=RANGE8A;
      TMPCNT8A=TMPCNT8;    TMPCNT8=TMPCNT9;    TMPCNT9=TMPCNT8A;
      VISCNT8A=VISCNT8;    VISCNT8=VISCNT9;    VISCNT9=VISCNT8A;
      CONDIT8A=CONDIT8;    CONDIT8=CONDIT9;    CONDIT9=CONDIT8A;
      CHNGFLAG=I;  END;
    IF (OTAZ9 GT OTAZI0) THEN DO;
      OTAZ9A=OTAZ9;        OTAZ9=OTAZI0;        OTAZI0=OTAZ9A;
      IDTGT9A=IDTGT9;      IDTGT9=IDTGTI0;      IDTGTI0=IDTGT9A;
      RANGE9A=RANGE9;      RANGE9=RANGE10;      RANGE10=RANGE9A;
      TMPCNT9A=TMPCNT9;    TMPCNT9=TMPCNT10;    TMPCNTI0=TMPCNT9A;
      VISCNT9A=VISCNT9;    VISCNT9=VISCNTI0;    VISCNTI0=VISCNT9A;
      CONDIT9A=CONDIT9;    CONDIT9=CONDITI0;    CDNDITI0=CONDIT9A;
      CHNGFLAG=I;  END;
    END;
**************** END OF SORT *********************************;
  ARRAY IDTGT (K) $ IDTGTI-IDTGT10;
  ARRAY POSITION (K) $ POSITNI-POSITNI0;
  ARRAY TGTYPE (K) $ TGTYPEI-TGTYPEI0;
  D=0;  TK=0;  B=0;  H=0;  U=0;  N=0;
  DO K=I TO I0;
    IF (SUBSTR(IDTGT,I,I)= 'T') THEN DO;
      IF (SUBSTR(IDTGT,2,I)= 'D') THEN DO; POSITION='DECOY'; D=D+I; END;
      IF SUBSTR(IDTGT,2,1)= 'T' OR SUBSTR(IDTGT,2,1)='D' THEN DO;
        POSITION ='TANK'; TK=TK+1; END;
      END;
    IF (SUBSTR(IDTGT,1,3)= 'BMP') THEN DO; POSITION='BMP'; B=B+1; END;
    IF (SUBSTR(IDTGT,1,2)= 'HK') THEN DO; POSITION='HULK'; H=H+1; END;
    IF (SUBSTR(IDTGT,1,3)= 'UNK') THEN DO; POSITION='UNK'; U=U+1; END;
    IF (SUBSTR(IDTGT,1,4)= 'NONE') THEN DO; POSITION='NONE'; N=N+1; END;
    TGTTYPE=POSITION;
    TGTYPE=POSITION;
    DECOY=D;  TANK=TK;  BMP=B;  HULK=H;  UNK=U;  NONE=N;
    END;
*****************************************************************;
PROC SORT;
  BY IDTRIAL IDOBS;
*PROC PRINT;
*  VAR IDTRIAL IDOBS POSITN1 POSITN2 POSITN3 POSITN4 POSITN5 POSITN6
*      POSITN7 POSITN8 POSITN9 POSITN10;
*  TITLE1 'OTAZ LISTING';
*  TITLE2 ' ';
*  TITLE3 'TARGET TYPES AT EACH POSITION FOR ALL TPOS TRIALS';
*PROC CHART;
* VBAR TGTTYPE / TYPE=PERCENT;
* TITLE1 'OTAZ LISTING';
* TITLE2 ' ';
* TITLE3 'PERCENTAGES OF TARGET TYPES AGREGATED OVER ALL TPOS TRIALS';
*PROC CHART;
*  VBAR POSITN1 POSITN2 POSITN3 POSITN4 POSITN5 POSITN6
*      POSITN7 POSITN8 POSITN9 POSITN10 /TYPE=PERCENT;
*  TITLE1 'OTAZ LISTING';
*  TITLE2 ' ';
*  TITLE3 'PERCENTAGES OF TARGET TYPE AT EACH POSITION';
*  TITLE4 'OVER ALL TPOS TRIALS';
*PROC FREQ;
*  TABLES TGTTYPE;
*  TABLES POSITN1 POSITN2 POSITN3 POSITN4 POSITN5 POSITN6 POSITN7
*         POSITN8 POSITN9 POSITN10;
*****************************************************************;
DATA DATAOUT.OTAZ;
  SET SIX;
PROC SORT;
  BY IDTRIAL IDOBS;
PROC PRINT;
  VAR IDTRIAL IDOBS IDTGT1 OTAZ1 RANGE1 IDTGT2 OTAZ2 RANGE2
    IDTGT3 OTAZ3 RANGE3 IDTGT4 OTAZ4 RANGE4 IDTGT5 OTAZ5 RANGE5
    IDTGT6 OTAZ6 RANGE6 IDTGT7 OTAZ7 RANGE7
    IDTGT8 OTAZ8 RANGE8 IDTGT9 OTAZ9 RANGE9 IDTGT10 OTAZ10 RANGE10;
  TITLE1 'OTAZ LISTING';
  TITLE2 ' ';
  TITLE3 'OBSERVER-TARGET AZIMUTHS (ASCENDING ORDER) AND RANGES';
  TITLE4 'FOR TPOS TRIALS';
*********************************;
*PROC PRINT;
*  VAR IDTRIAL IDOBS
*      LIGHTLVL TMPCNT1-TMPCNT10
*     VISCNT1-VISCNT10 CONDIT1-CONDIT10;
*  TITLE1 'TRIAL, OBSERVER, AND TARGET CONDITIONS (TPOS TRIALS)';
*  TITLE2 ' ';
*  TITLE3 'LIGHTLVL = LIGHT LEVEL (NIGHT TRIALS ONLY) IN FOOT CANDLES';
*  TITLE4 'TMPCNT = TEMPERATURE CONTRAST (TARGET TO BACKGROUND)';
*  TITLE5 'VISCNT = VISUAL CONTRAST (TARGET TO BACKGROUND)';
*  TITLE6 'CONDIT = CONDITIONS:';
*  TITLE7 'A=BASELINE        D=TGT CREW EXPOSED   G=TGT ENGINE RUNNING ';
*  TITLE8 'B=TGT MOVEMENT    E=PARTIAL EXPOSURE   SIL=SILHOUETTED STMMS';
*  TITLE9 'C=TGT FIRING CUE  F=FULL CONCEALMENT   CON=CONCEALED STMMS  ';
**************************************;
/*
//
```

APPENDIX C

FOVALL SAS PROGRAM

```
//FOVALL  JOB (1477,9999),'DUBOIS',CLASS=C
//*MAIN SYSTEM=SY2,CARDS=(80),LINES=(200)
//*
//*
//*  THIS PROGRAM CREATES A 600 ELEMENT ARRAY OF THE FOV CODE FOR EACH
//*    SECOND OF THE TPOS TRIALS.  THE RAW DATA IS IN MSS.F1742.TPOS.
//*    THIS PROGRAM CREATES A SAS DATA SET CALLED DATAOUT.FOVALL (IN
//*    MSS.S1477.FOVALL).
//*
//  EXEC SAS,REGION=6000K
//WORK DD SPACE=(CYL,(16,16))
//DATAIN DD DISP=SHR,DSNAME=MSS.F1742.TPOS
//DATAOUT DD DISP=(OLD,KEEP),DSNAME=MSS.S1477.FOVALL
//SYSIN DD *
OPTIONS LINESIZE = 132;
DATA ONE;
  INFILE DATAIN;
  INPUT RECTYPE $ 1 @;
**************************************;
  IF (RECTYPE = 'H') THEN DO;
    INPUT #1  RECTYPE $ 1  IDTRIAL $ 2-6  TRLSTIM 15-20
         #9;
    DELETE;
    DETCOUNT=0;
    END;
**************************************;
  IF (RECTYPE = 'E') THEN DO;
    INPUT #1  IDOBS $ 2-5  IDTGT $ 6-9  ATGTTYPE 12  TMOTION 14
              DETRANGE 21-24  SRMODE1A 28  SRMODTIM 29-34  SRMODNEW 35
              SRMOFLAG 36  TSFOV1 46  TSFOVTIM 47-52  TSFOV 53
              FOVFLAG 54  STSRTIM 55-60 STSRAZ 61-66  TGTFIRTM 67-72
           #2 DETECTIM 1-6  DETECTAZ 14-19  AIMTIM 20-25  AIMAZ 26-31
              RECOGTIM 38-43  FIRETIM 44-49  FIREAZ 51-56
           #4 SSTTODET 15-17  CUETODET 18-20  DETTOREC 21-23
              RECTOFIR 24-26;
    END;
**************************************;
  IF RECTYPE = 'C' THEN DO;
    IF (SRMOFLAG=2) OR (FOVFLAG=2) THEN DO;
      INPUT #1  IDOBS $ 2-5  SRMODTIM 6-11  SRMODE1A 12
              TSFOVTIM 62-67 TSFOV 68
            #4;
      END;
    ELSE DO;
      INPUT #4;
      DELETE;
      END;
    END;
**************************************;
* IF (SUBSTR(IDTRIAL,3,1) NE '0') THEN DELETE;
  IF (SUBSTR(IDOBS,1,2) EQ 'AP') THEN DELETE;
**************************************;
  START=.;
  IF (TRLSTIM LE 240000) THEN DO;
    HOURS=INT(TRLSTIM/10000);
    MINUTES=INT((TRLSTIM-HOURS*10000)/100);
    SECONDS=INT(TRLSTIM-(HOURS*10000)-(MINUTES*100));
    START=HOURS*3600+MINUTES*60+SECONDS;
    END:
******** THIS RDUTINE CONVERTS DETECTIM TD SECDNDS-INTO-TRIAL ********;
  DETECT=.;
  IF (OETECTIM LE 240000) THEN DO:
    HOURS=INT(DETECTIM/10000);
    MINUTES=INT((DETECTIM-HOURS*I0000)/100);
    SECONOS=INT(DETECTIM-(HOURS*I0000)-(MINUTES*100));
    OETECTIM=HOURS*3600+MINUTES*60+SECONOS;
    DETECT=OETECTIM-START;
    ENO;
  IF OETECT GT 600 THEN OELETE;
******** THIS ROUTINE CONVERTS TSFOVTIM TO SECDNDS-INTO-TRIAL ********;
  FOVCHNG=.;
  IF (TSFOVTIM LE 240000) THEN OO:
    HOURS=INT(TSFOVTIM/I0000);
    MINUTES=INT((TSFOVTIM-HOURS*I0000)/100);
    SECONOS=INT(TSFOVTIM-(HOURS*I0000)-(MINUTES*100));
    CHNGTIME=HOURS*3600+MINUTES*60+SECONOS;
    FOVCHNG=CHNGTIME-START;
    END:
  IF FOVCHNG GT 600 THEN OELETE:
************************************;
  KEEP IOTRIAL IDDBS IDTGT
   TSFOVTIM TSFOV OETECTIM IDOBSLAG
   FOVCHNG TRLSTIM NUM TSFOVI FOVFLAG SRMOFLAG
   FOVCHNG1 OETECT FOV1-FDV600 DETCDUNT;
************************************;
  ARRAY FOV (I) FOVI-FOV600:
  IOOBSLAG=LAG(IOOBS):
  IF (IOOBS NE IOOBSLAG) THEN DO:
    OETCOUNT = 0:
    NUM=0;
    OO I = 1 TO 600:
      FOV=TSFOVI;
      ENO:
    ENO:
  IF (DETECT NE .) THEN OETCOUNT=DETCDUNT+1;
************************************;
  IF FOVCHNG NE . THEN OO:
    FOVCHNGI=FOVCHNG:
    NUM=NUM+1;
    IF NUM=I THEN DD:
      DO I=I TO FOVCHNG-1;
        FOV=TSFOV1;
        END:
      OO I= FOVCHNG TO 600:
        FOV=TSFOV:
        ENO;
      ENO:
    ELSE OO:
      OO I=FOVCHNG1 TO FOVCHNG-1:
        FOV=TSFOVI:
        ENO:
      OO I= FOVCHNG TO 600:
        FOV=TSFOV:
        ENO:
      ENO:
    ENO:
```

```
*************************************;
  RETAIN IDTRIAL TRLSTIM SRMDFLAG FOVFLAG IDOBS IDTGT
    NUM IDOBSLAG DETCOUNT FOVCHNG FOV1-FOV600:
*************************************;
PROC SORT DATA=ONE:
  BY IDTRIAL IDOBS:
*************************************;
DATA TWO:
  SET ONE;
PROC MEANS DATA=TWO MAXDEC=3 MAX ;
  VAR DETCOUNT;
  BY IDTRIAL IDOBS:
  OUTPUT OUT=THREE MAX=TOTDTECT;
*************************************;
PROC SORT DATA=THREE;
  BY IDTRIAL IDOBS:
*************************************;
DATA FOUR;
  MERGE ONE THREE;
    BY IDTRIAL IDOBS:
  RETAIN TOTDECT;
  ARRAY FOV (I) FOV1-FOV600;
  IF DETCOUNT NE TOTDTECT THEN DELETE;
  KEEP IDTRIAL IDOBS DETCOUNT TOTDTECT FOV1-FOV600;
PROC SORT;
  BY IDTRIAL IDOBS:
*************************************;
DATA DATAOUT.FOVALL;
  MERGE ONE FOUR;
  KEEP IDTRIAL IDOBS DETCOUNT FOV1-FOV600 TOTDTECT;
PROC SORT;
  BY IDTRIAL IDOBS:
*PROC PRINT;
*  VAR IDTRIAL IDOBS FOV1-FOV600;
*  TITLE1 'FOVALL LISTING';
*  TITLE2 ' ';
*  TITLE3 'FOV1-FOV600 FOR TPDS TRIALS';
/*
//
```

APPENDIX D

DTECTALL SAS PROGRAM

```
//DTECTALL  JDB (1477,9999),'DUBOIS',CLASS=C
//*MAIN SYSTEM=SY2,CARDS=(100),LINES=(100)
//*
//* THIS PROGRAM PRINTS A TABLE OF TIMES TO DETECT THE TARGETS 1 THRU 10.
//* THE ORIGINAL DATA IS FROM MSS.F1742.TPDS.  IN ADDITION, THIS
//* PROGRAM DETERMINES FIRST DETECTIONS.  IT CREATES A SAS DATASET CALLED
//* DATADUT.DTECTALL (IN MSS.S1477.DTECTALL).
//*
//  EXEC SAS V5,REGION=1200K
//WORK DD SPACE=(CYL,(8,8))
//DATAIN DD DISP=SHR,DSNAME=MSS.F1742.TPDS
//DATAOUT DD DISP=(OLD,KEEP),DSNAME=MSS.S1477.DTECTALL
//SYSIN DD *
OPTIONS LINESIZE = 132; *PAGESIZE=60;
*************************************;
*************************************;
DATA ONE;
  INFILE DATAIN;
  INPUT RECTYPE $ 1 @;
*************************************;
  IF (RECTYPE = 'H') THEN DO;
    INPUT #1  RECTYPE $ 1  IDTRIAL $ 2-6  TRLSTIM 15-20
              OBS1 $ 21-24  MOPGEAR1 $ 31  AZADJ1 32-37  OBS2 $ 48-51
              MDPGEAR2 $ 58  AZADJ2 59-64
              OBS3 $ 75-78
          #2  MOPGEAR3 $ 7  AZADJ3 8-13  OBS4 $ 24-27  MOPGEAR4 $ 34
              AZADJ4 35-40
          #3  TRLSITE 18  AIRTEMP 40-43  VISIBLTY 56-59
          #9;
    DELETE;
    DETCOUNT=0;
    END;
*************************************;
  IF (RECTYPE = 'E') THEN DO;
    INPUT #1  IDDBS $ 2-5  TARGET $ 6-9  ATGTTYPE 12  EXPOSE 13
              MOTION 14  CAMOUF 15  TGTENGIN 16
              DETRANGE 21-24  TCSRMODE 28  SRMODTIM 29-34  SRMODNEW 35
              SRMDFLAG 36  SITEFOV 46  TSFOVTIM 47-52  TSFOVNEW 53
              FDVFLAG 54  STSRTIM 55-60 STSRAZ 61-66  TGTFIRTM 67-72
          #2  DETECTIM 1-6  DETECTAZ 14-19  AIMTIM 20-25  AIMAZ 26-31
              RECOGTIM 38-43  FIRETIM 44-49  FIREAZ 51-56  MEMBER $ 74
          #4  SSTTODET 15-17  CUETODET 18-20  DETTOREC 21-23
              RECTOFIR 24-26;
    END;
*************************************;
  IF RECTYPE = 'C' THEN DO;
    IF (SRMDFLAG=2) DR (FOVFLAG=2) THEN DO;
      INPUT #1  IDOBS $ 2-5  SRMODTIM 6-11  TCSRMODE 12
              TSFOVTIM 62-67 TSFOVNEW 68
            #4;
      END;
    ELSE DD;
      INPUT #4;
      DELETE;
      END;
    END;
*************************************;
* IF IDTRIAL='DS021' OR IDTRIAL='DS028' OR IDTRIAL='DS029';
```

```
  IF (SUBSTR(IDOBS,I,2) EQ 'AP') THEN DELETE;
  IF (DETECTAZ GT 360) THEN DETECTAZ =.;
  IF (FIREAZ GT 360) THEN FIREAZ =.;
  IF DETRANGE GT 7777 THEN DETRANGE =.;
************************************;
  RETAIN IDTRIAL TRLSTIM SRMDFLAG FOVFLAG IDOBS TARGET ATGTTYPE
    HATCH AZADJI AZADJ2 AZADJ3 AZADJ4
    DETCOUNT FOVCHNG OBS1 OBS2 OBS3 OBS4
    TRLSITE AIRTEMP VISIBLTY
    NOMRANGE MOPGEARI MOPGEAR2 MOPGEAR3 MOPGEAR4;
************************************;
  START=.;
  IF (TRLSTIM LE 240000) THEN DO;
    HOURS=INT(TRLSTIM/I0000);
    MINUTES=INT((TRLSTIM-HOURS*I0000)/I00);
    SECONDS=INT(TRLSTIM-(HOURS*I0000)-(MINUTES*I00));
    START=HOURS*3600+MINUTES*60+SECONDS;
    END;
******** THIS ROUTINE CONVERTS TSFOVTIM TO SECONDS-INTO-TRIAL ******;
  FOVCHNG=.;
  IF (TSFOVTIM LE 240000) THEN DO;
    HOURS=INT(TSFOVTIM/I0000);
    MINUTES=INT((TSFOVTIM-HOURS*I0000)/I00);
    SECONDS=INT(TSFOVTIM-(HOURS*I0000)-(MINUTES*I00));
    CHNGTIME=HOURS*3600+MINUTES*60+SECONDS;
    FOVCHNG=CHNGTIME-START;
    END;
  IF FOVCHNG GT 600 THEN DELETE;
******** THIS ROUTINE CONVERTS STSRTIM TO SECONDS-INTO-TRIAL ********;
  IF STSRTIM GT 240000 THEN DELETE;
  IF (STSRTIM LE 240000) THEN DO;
    HOURS=INT(STSRTIM/I0000);
    MINUTES=INT((STSRTIM-HOURS*I0000)/I00);
    SECONDS=INT(STSRTIM-(HOURS*I0000)-(MINUTES*I00));
    STSRTIM=HOURS*3600+MINUTES*60+SECONDS;
    STSEARCH=STSRTIM-START;
    END;
  IF (STSEARCH LE I) THEN STSEARCH =1;
  IF STSEARCH GT 600 THEN DELETE;
******** THIS ROUTINE CONVERTS SRMODTIM TO SECONDS-INTO-TRIAL ********;
  SMODCHNG=.;
  IF (SRMODTIM LE 240000) THEN DO;
    HOURS=INT(SRMODTIM/I0000);
    MINUTES=INT((SRMODTIM-HOURS*I0000)/I00);
    SECONDS=INT(SRMODTIM-(HOURS*I0000)-(MINUTES*I00));
    SRMODTIM=HOURS*3600+MINUTES*60+SECONDS;
    SMODCHNG=SRMODTIM-START;
    END;
******** THIS ROUTINE CONVERTS DETECTIM TO SECONDS-INTO-TRIAL ********;
  IF DETECTIM GT 240000 THEN DELETE;
  IF (DETECTIM LE 240000) THEN DO;
    HOURS=INT(DETECTIM/I0000);
    MINUTES=INT((DETECTIM-HOURS*I0000)/I00);
    SECONDS=INT(DETECTIM-(HOURS*I0000)-(MINUTES*100));
    DETECTIM=HOURS*3600+MINUTES*60+SECONDS;
    DETECT=DETECTIM-START;
    END;
  IF DETECT EQ STSEARCH THEN DO;
```

```
    DETECT=DETECT+1;  SSTTODET=SSTTODET+1;  END;
  IF DETECT LE 1 OR DETECT GT 600 OR DETECT EQ . THEN DELETE;
******** THIS ROUTINE CONVERTS FIRETIM TO SECONDS-INTO-TRIAL ********;
  FIRE=.;
  IF (FIRETIM LE 240000) THEN DO;
    HOURS=INT(FIRETIM/10000);
    MINUTES=INT((FIRETIM-HOURS*10000)/100);
    SECONDS=INT(FIRETIM-(HOURS*10000)-(MINUTES*100));
    FIRETIM=HOURS*3600+MINUTES*60+SECONDS;
    FIRE=FIRETIM-START;
    END;
******** THIS SECTION CONVERTS NUMERIC CODES INTO CHARACTERS ********;
  IF (ATGTTYPE= 1) THEN TGTTYPE = ' TANK';
  IF (ATGTTYPE= 2) THEN TGTTYPE = ' APC ';
  IF (ATGTTYPE= 3) THEN TGTTYPE = ' HULK';
  IF (ATGTTYPE= 4) THEN TGTTYPE = 'DECOY';
  IF (ATGTTYPE= 5) THEN TGTTYPE = 'FALSE';
  IF (ATGTTYPE= 9) THEN TGTTYPE = ' UNK ';
  IF SITEFOV= 1 THEN SIGHTFOV = '2.5 DEG';
  IF SITEFOV= 2 THEN SIGHTFOV = ' 15 DEG';
  IF SITEFOV= 8 THEN SIGHTFOV = '  8 DEG';
  IF SITEFOV= 9 THEN SIGHTFOV = '   UNK ';
  IF DETRANGE NE . AND DETRANGE LE 1200 THEN NOMRANGE='SHRT';
  IF DETRANGE GT 1200 AND DETRANGE LE 2200 THEN NOMRANGE='MEDM';
  IF DETRANGE GT 2200 AND DETRANGE LE 3500 THEN NOMRANGE='LONG';
  IF MEMBER='1' THEN CREWMEMB='TCOR';
  IF MEMBER='2' THEN CREWMEMB='GUNR';
  IF MEMBER='0' THEN CREWMEMB=' UNK';
  IF MOTION = 1 THEN TMOTION='STILL ';
  IF MOTION = 2 THEN TMOTION='MOVING';
  IF MOTION = 8 THEN TMOTION='  N/A ';
  IF MOTION = 9 THEN TMOTION='  UNK ';
  IF CAMOUF=1 THEN CAMOUFLG='NONE';
  IF CAMOUF=2 THEN CAMOUFLG='PART';
  IF CAMOUF=3 THEN CAMOUFLG='FULL';
  IF CAMOUF=8 THEN CAMOUFLG=' N/A';
  IF CAMOUF=9 THEN CAMOUFLG=' UNK';
  IF EXPOSE =1 THEN TGTEXPOS='YES';
  IF EXPOSE =2 THEN TGTEXPOS=' NO';
  IF EXPOSE =8 THEN TGTEXPOS='N/A';
  IF EXPOSE =9 THEN TGTEXPOS='UNK';
  IF TGTENGIN=1 THEN ENGINE='OFF';
  IF TGTENGIN=2 THEN ENGINE='RUN';
  IF TGTENGIN=8 THEN ENGINE='N/A';
  IF TGTENGIN=9 THEN ENGINE='UNK';
*************************************;
  IF IDOBS=OBS1 THEN DO;
     IF TCSRMODE=1 OR TCSRMODE=2 THEN SRCHMODE='EYE/OPT';
     ELSE SRCHMODE='OPT/OPT';
     HATCH='CLOSED'; MOP=MOPGEAR1; END;
  IF IDOBS=OBS2 THEN DO;
     IF TCSRMODE=1 OR TCSRMODE=2 THEN SRCHMODE='EYE/OPT';
     ELSE SRCHMODE='OPT/OPT';
     HATCH='OPEN';  MOP=MOPGEAR2;  END;
  IF IDOBS=OBS3 THEN DO;
     IF TCSRMODE=1 OR TCSRMODE=2 THEN SRCHMODE='EYE/THM';
     ELSE SRCHMODE='THM/THM';
     HATCH='CLOSED';  MOP=MOPGEAR3;  END;
  IF IDOBS=OBS4 THEN DO:
     IF TCSRMODE=1 OR TCSRMODE=2 THEN SRCHMODE='EYE/THM';
     ELSE SRCHMODE='THM/THM';
     HATCH='OPEN';  MOP=MOPGEAR4;  END;
    IF MOP='0' THEN MOPP=' NO';
    IF MOP='I' THEN MOPP='YES';
*************************************;
  IF HATCH='OPEN' AND (CREWMEMB='TCDR' OR CREWMEMB=' UNK') THEN DO;
    IF SMODCHNG NE . THEN DO;
      IF (TCSRMODE=1 OR TCSRMODE=2) AND DETECT LT SMODCHNG THEN DELETE;
      IF (TCSRMODE=3 OR TCSRMODE=4) AND DETECT GT SMODCHNG THEN DELETE;
      IF TCSRMODE NE 1 AND TCSRMODE NE 2 AND TCSRMODE NE 3 AND
        TCSRMODE NE 4 THEN DELETE;
      END;
    IF SMODCHNG =. AND (TCSRMODE NE 3 AND TCSRMODE NE 4) THEN DELETE;
    END;
 * (TCSRMODE CODES: 1=EYE            2=BINOCULARS       3=OPTICAL SIGHT ;
 *                  4=THERMAL SIGHT  5=N/A (TOW ONLY)  6=UNKNOWN        );
 * (THE ABOVE LINES DELETE DETECTIONS MADE WITH OPEN HATCH BY CREWMEMB
 * 'TCDR' OR 'UNK' USING EYE SEARCHMODE OR WHEN SIGHT TYPE IS UNKNOWN');
*************************************;
  IF IDOBS NE LAG(IDOBS) THEN DETCOUNT = 0;
  DETCOUNT=DETCOUNT+1;
*************************************;
PROC SORT;
  BY IDTRIAL IDOBS;
*************************************;
*************************************;
DATA TWO;
  SET ONE;
  DROP MOPGEAR1-MOPGEAR4 MOP ATGTTYPE MEMBER CAMOUF EXPOSE TGTENGIN;
  DETECTIM=DETECT;
  FIRSTDET=0;
*************************************;
*************************************;
DATA THREE1;
  SET TWO;
  IF (TARGET NE 'BMP1') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE2;
  SET TWO;
  IF (TARGET NE 'BMP2') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE3;
  SET TWO;
  IF (TARGET NE 'BMP3') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE4;
  SET TWO;
  IF (TARGET NE 'BMP4') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE5;
  SET TWO;
  IF (TARGET NE 'T01') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE6;
  SET TWO;
  IF (TARGET NE 'T02') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE7;
  SET TWO;
  IF (TARGET NE 'T03') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE8;
  SET TWO;
  IF (TARGET NE 'T04') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE9;
  SET TWO;
  IF (TARGET NE 'T05') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE10;
  SET TWO;
  IF (TARGET NE 'T06') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE11;
  SET TWO;
  IF (TARGET NE 'T07') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE12;
  SET TWO;
  IF (TARGET NE 'TD1') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE13;
  SET TWO;
  IF (TARGET NE 'TD2') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE14;
  SET TWO;
  IF (TARGET NE 'TT2') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE15;
  SET TWO;
  IF (TARGET NE 'HK41') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE16;
  SET TWO;
  IF (TARGET NE 'HK42') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE17;
```

```
  SET TWO;
  IF (TARGET NE 'HK51') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE18;
  SET TWO;
  IF (TARGET NE 'HK52') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE19;
  SET TWO;
  IF (TARGET NE 'UNK') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA THREE20;
  SET TWO;
  IF (TARGET NE 'NONE') THEN DELETE;
  IF IDOBS NE LAG(IDOBS) OR IDTRIAL NE LAG(IDTRIAL) THEN FIRSTDET=1;
*************************************;
DATA FOUR;
  SET THREE1 THREE2 THREE3 THREE4 THREE5 THREE6 THREE7 THREE8 THREE9
    THREE10 THREE11 THREE12 THREE13 THREE14 THREE15 THREE16 THREE17
    THREE18 THREE19 THREE20;
PROC SORT;
  BY IDTRIAL IDOBS $TSEARCH;
*************************************;
DATA DATAOUT.DTECTALL;
  SET FOUR;
  KEEP IDTRIAL IDOBS STSEARCH SIGHTFOV FOVCHNG DETECTIM DETCOUNT
     AZADJ1 AZADJ2 AZADJ3 AZADJ4
     TCSRMODE CAMOUFLG ENGINE CREWMEMB FIRSTDET HATCH MOPP NOMRANGE
     DETTODET DETIMLAG TGTEXPOS TRLSITE AIRTEMP VISIBLTY
     DETECTAZ DETRANGE SSTTODET TARGET TGTTYPE SRCHMODE SMODCHNG;
  DETIMLAG=LAG(DETECTIM);
  IF DETCOUNT = 1 THEN DETTODET=DETECTIM;
  ELSE DETTODET=(DETECTIM-DETIMLAG);
PROC PRINT;
  VAR IDTRIAL IDOBS DETCOUNT TARGET DETECTIM DETECTAZ DETRANGE
                             TRLSITE AIRTEMP VISIBLTY MOPP HATCH
  SRCHMODE TCSRMODE STSEARCH SMODCHNG SIGHTFOV FOVCHNG CREWMEMB
  FIRSTDET SSTTODET DETTODET TGTTYPE;
  TITLE1 'DTECTALL LISTING';
  TITLE2 ' ';
  TITLE3 'TIMELINE FOR ALL DETECTIONS (USING SIGHTS) IN TPDS TRIALS';
  TITLE4 'AND SOME OBSERVER AND TARGET CONDITIONS';
***************;
***************;
DATA FIVE;
  SET DATAOUT.DTECTALL;
  IF FIRSTDET=1;
  IF TGTTYPE='UNK' OR TGTTYPE='FALSE' THEN DELETE;
  TITLE1 'DTECTALL CHART FROM TPDS DATA (FIRST DETECTIONS ONLY)';
  TITLE2 ' ';
*PROC PLOT;
*  PLOT _N_*SSTTODET / VAXIS=0 TO 200 BY 5  VPOS=110  HPOS=60;
*  TITLE3 'DISTRIBUTION OF SSTTODET';
*  TITLE4 '(SECONDS FROM START SEARCH TO DETECT)';
*  TITLE5 ' ';
*  TITLE6 'ALL SSTTODET';
*  PLOT _N_*DETTODET / VAXIS=0 TO 200 BY 5  VPOS=110  HPOS=60;
*  TITLE3 'DISTRIBUTION OF DETTODET';
*  TITLE4 '(SECONDS FROM LAST DETECT TO DETECT)';
*  TITLE6 'ALL DETTODET';
*PROC CHART;
*  VBAR SSTTODET / TYPE=PERCENT
*    MIDPOINTS= 10 30 50 70 90 110 130 150 170 190;
*  TITLE3 'DISTRIBUTION OF SSTTODET';
*  TITLE4 '(SECONDS FROM START SEARCH TO DETECT)';
*  TITLE5 ' ';
*  TITLE6 'ALL SSTTODET';
*PROC CHART;
*  VBAR DETTODET / TYPE=PERCENT
*    MIDPOINTS= 10 30 50 70 90 110 130 150 170 190;
*  TITLE3 'DISTRIBUTION OF DETTODET';
*  TITLE4 '(SECONDS FROM LAST DETECT TO DETECT)';
*  TITLE6 'ALL DETTODET';
*PROC SORT;
*  BY TGTTYPE;
*PROC CHART;
*  VBAR SSTTODET /TYPE=PERCENT
*    MIDPOINTS= 10 30 50 70 90 110 130 150 170 190;
*  BY TGTTYPE;
*  TITLE3 'DISTRIBUTION OF SSTTODET';
*  TITLE4 '(SECONDS FROM START SEARCH TO DETECT)';
*  TITLE5 ' ';
*  TITLE6 'BY TARGET TYPE (TANK, BMP, DECOY, OR HULK)';
*PROC CHART;
*  VBAR DETTODET / TYPE=PERCENT
*    MIDPOINTS= 10 30 50 70 90 110 130 150 170 190;
*  BY TGTTYPE;
*  TITLE3 'DISTRIBUTION OF DETTODET';
*  TITLE4 '(SECONDS FROM LAST DETECT TO DETECT)';
*  TITLE5 ' ';
*  TITLE6 'BY TARGET TYPE (TANK, BMP, DECOY, OR HULK)';
*PROC SORT;
* BY NOMRANGE;
*PROC CHART;
*  VBAR SSTTODET /TYPE=PERCENT
*    MIDPOINTS= 10 30 50 70 90 110 130 150 170 190;
*  BY NOMRANGE;
*  TITLE3 'DISTRIBUTION OF SSTTODET';
*  TITLE4 '(SECONDS FROM START SEARCH TO DETECT)';
*  TITLE5 ' ';
*  TITLE6 'BY NOMINAL RANGE (SHORT,MEDIUM, OR LONG)';
*PROC CHART;
*  VBAR DETTODET / TYPE=PERCENT
*    MIDPOINTS= 10 30 50 70 90 110 130 150 170 190;
*  BY NOMRANGE;
*  TITLE3 'DISTRIBUTION OF DETTODET';
*  TITLE4 '(SECONDS FROM LAST DETECT TO DETECT)';
*  TITLE5 ' ';
*  TITLE6 'BY NOMINAL RANGE (SHORT,MEDIUM, OR LONG)';
*PROC SORT;
* BY MOPP;
*PROC CHART;
*  VBAR SSTTODET /TYPE=PERCENT
*    MIDPOINTS= 10 30 50 70 90 110 130 150 170 190;
*  BY MOPP;
*  TITLE3 'DISTRIBUTION OF SSTTODET';
*  TITLE4 '(SECONDS FROM START SEARCH TO DETECT)';
*  TITLE5 ' ';
*  TITLE6 'BY MOPP STATUS';
*PROC CHART;
*  VBAR DETTODET / TYPE=PERCENT
*    MIDPOINTS= 10 30 50 70 90 110 130 150 170 190;
*  BY MOPP;
*  TITLE3 'DISTRIBUTION OF DETTODET';
*  TITLE4 '(SECONDS FROM LAST DETECT TO DETECT)';
*  TITLE5 ' ';
*  TITLE6 'BY MOPP STATUS';
***************;
***************;
DATA SIX;
  SET FIVE;
  IF SRCHMODE='OPT/OPT' OR ((SRCHMODE='EYE/OPT' OR SRCHMODE='EYE/THM')
    AND CREWMEMB='TCDR');
  TITLE6 'DETECTIONS USING OPTICAL SIGHT OR UNAIDED VISUAL';
**************;
**************;
*DATA SEVEN;
*  SET FIVE;
*  IF SRCHMODE='THM/THM' OR (SRCHMODE='EYE/THM' AND CREWMEMB='GUNR');
*  TITLE6 'DETECTIONS USING THERMAL SIGHT';
*PROC SORT;
* BY ENGINE;
*PROC CHART;
*  VBAR SSTTODET/TYPE=PERCENT
*    MIDPOINTS= 10 30 50 70 90 110 130 150 170 190;
*  BY ENGINE;
*  TITLE3 'DISTRIBUTION OF SSTTODET';
*  TITLE4 '(SECONDS FROM START SEARCH TO DETECT)';
*  TITLE5 ' ';
*  TITLE7 'BY ENGINE STATUS (OFF, RUNNING, OR N/A (HULK OR DECOY))';
*PROC CHART;
*  VBAR DETTODET/TYPE=PERCENT
*    MIDPOINTS= 10 30 50 70 90 110 130 150 170 190;
*  BY ENGINE;
*  TITLE3 'DISTRIBUTION OF DETTODET';
*  TITLE4 '(SECONDS FROM LAST DETECT TO DETECT)';
*  TITLE5 ' ';
*  TITLE7 'BY ENGINE STATUS (OFF, RUNNING, OR N/A (HULK OR DECOY))';
*PROC PLOT;
*  PLOT AIRTEMP*SSTTODET;
*  TITLE7 'BY AIR TEMPERATURE (DEGREES CELSIUS)';
***************;
***************;
*DATA EIGHT;
*  SET FIVE;
*  IF SRCHMODE='OPT/OPT' OR SRCHMODE='THM/THM' OR CREWMEMB='GUNR';
*  TITLE6 'DETECTIONS USING OPTICAL OR THERMAL SIGHT';
*PROC SORT;
*  BY SIGHTFOV;
*PROC CHART;
*  VBAR SSTTODET/TYPE=PERCENT
*    MIDPOINTS= 10 30 50 70 90 110 130 150 170 190;
*  BY SIGHTFOV;
*  TITLE3 'DISTRIBUTION OF SSTTODET';
*  TITLE4 '(SECONDS FROM START SEARCH TO DETECT)';
*  TITLE5 ' ';
*  TITLE7 'BY SIGHT FIELD OF VIEW (5 OR 15 DEGREES)';
*PROC CHART;
*  VBAR DETTODET/TYPE=PERCENT
*    MIDPOINTS= 10 30 50 70 90 110 130 150 170 190;
*  BY SIGHTFOV;
*  TITLE3 'DISTRIBUTION OF DETTODET';
*  TITLE4 '(SECONDS FROM LAST DETECT TO DETECT)';
*  TITLE5 ' ';
*  TITLE7 'BY SIGHT FIELD OF VIEW (5 OR 15 DEGREES)';
***************;
***************;
/*
//
```

APPENDIX E

TIMINFOV SAS PROGRAM

```
//TIMINfov JOB (I477,9999),'DUBOIS',CLASS=C
//*MAIN SYSTEM=SY2,CARDS=(I00)
//*
//* THIS PROGRAM RETRIEVES THE FOLLOWING FOR EACH OBSERVER IN EACH TRIAL:
//*  I) 600 OBSERVER SIGHT AZIMUTHS FROM SAS OATA SET DATAOUT.AZIMUTH;
//*  2)  I0 OBSERVER-TARGET AZIMUTHS, RANGES, AND MANY OTHER TARGET
//*          VARIABLES FROM SAS DATA SET DATAOUT.OTAZ;
//*  3) 600 ELEMENT FIELD OF VIEW ARRAY FROM SAS OATA SET DATAOUT.FOVALL;
//*  4) THE DETECTION TIMELINE AND MANY TRIAL, OBSERVER, ANO TARGET
//*        CONDITIONS LOCATED IN SAS OATA SET DATAOUT.DTECTALL;
//*  5) THE DETECT TIMES SSTTODET ANO OETTODET FROM DTECTALL.
//*
//* FROM ALL THIS DATA, THIS PROGRAM COMPUTES FOR EACH OBSERVER:
//*  I) THE NUMBER OF SECONOS EACH TARGET IS WITHIN THE FIELD OF VIEW;
//*  2) THE NUMBER OF TIMES EACH TARGET ENTERS THE FIELD OF VIEW;
//*  3) WHICH TARGETS WERE OETECTEO OURING THE TRIAL (BY THAT OBSERVER);
//*  4) THE TOTAL OBSERVERS EACH TARGET WAS OETECTED IN THE TRIAL.
//*  5) SORTS THE TARGETS BOTH GEOMETRICALLY ANO CHRONOLOGICALLY.
//* ALL THE PERTINENT TARGET VARIABLES, SUCH AS CAMOUFLAGE, AND ENGINE
//*   STATUS, ARE ALSO SORTEO GEOMETRICALLY ANO CHRONOLOGICALLY, TO
//*   MATCH THE TARGET SORT.
//*
//* THIS PROGRAM ALSO COMPUTES THE UNIVARIATE STATISTICS ON THE THREE
//*   TIMES TO DETECTION: DETDET, SRCHDT, AND FOVDET.
//* VERTICAL BAR CHARTS FOR THE THREE TIMES BY POSITION, AND BY SEQUENCE
//*   ARE ALSO PROOUCED.
//*  NOT ALL THIS CAN BE DONE IN ONE RUN, SO THE UNWANTED PORTIONS
//*   ARE COMMENTEO OUT.
//*
// EXEC SAS V5,REGION=3200K
//WORK DO SPACE=(CYL,(2B,2B))
//DATAINI DD DISP=SHR,DSNAME=MSS.SI477.OTAZ
//OATAIN2 DD DISP=SHR,DSNAME=MSS.SI477.AZIMTEST
//DATAIN3 DO OISP=SHR,DSNAME=MSS.SI477.DTECTALL
//DATAIN4 DD DISP=SHR,DSNAME=MSS.SI477.FOVALL
//DATAOUT DD DISP=(OLD,KEEP),OSN=MSS.S1477.TIMINFOV
//SYSIN DD *
OPTIONS LINESIZE=132  PAGESIZE=60;
*************;
*************;
DATA ONE;
  MERGE DATAINI.OTAZ
        DATAIN2.AZIMTEST
        OATAIN3.DTECTALL
        OATAIN4.FOVALL;
    BY IDTRIAL IOOBS:
*******************************;
* IF IOTRIAL= 'DS020' OR IDTRIAL= 'DS02I' OR IDTRIAL='DS028';
* IF SUBSTR(IDTRIAL,3,I) EQ '0';
*************;
*************;
OATA ONEA;
  RETAIN IDTRIAL IDOBS STSEARCH;
  SET ONE;
PROC SORT;
  BY IDTRIAL IOOBS STSEARCH:
*************;
*************;
```

```
DATA TWO;
  SET ONEA;
  RETAIN FOVDET1-FOVDET10 NUMFOV1-NUMFOV10 STPCNT1-STPCNT10;
  DROP SMOOCHNG TCSRMODE;
**********************************************************;
  IF AZ100=. AND AZ200=. THEN DELETE;  *(AZIMUTH DATA IS MISSING FROM  ;
*   THESE TRIALS:   DS001 (FT03), DS048 (FT04), DS057 (FT04),;
*     DS058 (FT04), DS059 (FT04), DS168 (ALL),  DS169 (ALL),;
*     DS170 (ALL),  DS177 (FT11), DS179 (FT11), DS180 (FT11),;
*     DS181 (FT11), DS256 (ALL),  DS264 (FT02), DS276 (FT01) ) ;
  IF STSEARCH=LAG(STSEARCH) THEN DELETE;  *(THIS IS REQUIRED FROM THE   ;
     * EFFECT OF THE MERGE IN DATA ONE.  NO DATA IS LOST HERE)          ;
  IF STSEARCH=. THEN DELETE;  * (THIS IS REQUIRED BECAUSE IN DTECTALL,  ;
   * WE DELETED ENGAGEMENTS WHERE SRCHMODE=' ' OR 'UNK'.  THIS DELETED  ;
   * THE FOLLOWING DATA: DS029 (FT02), DS048 (FT04), AND DS256 (FT12));
**********************************************************;
**********************************************************;
  ARRAY IDTGT (I) IDTGT1-IDTGT10;
  ARRAY DTAZ (I) DTAZ1-DTAZ10;
  ARRAY TIMIN (I) TIMIN1-TIMIN10;
  ARRAY NUMIN (I) NUMIN1-NUMIN10;
  ARRAY AZ (J) AZ1-AZ600;
  ARRAY FOV (J) FOV1-FOV600;
  ARRAY NUM (K) NUM1-NUM600;
  ARRAY FOVDET (I) FOVDET1-FOVDET10;
  ARRAY NUMFOV (I) NUMFOV1-NUMFOV10;
  ARRAY STPCNT (I) STPCNT1-STPCNT10;
***** RESET FOR EACH OBSERVER ***************;
  * IDOBS IS THE NAME FROM DTAZ AND FROM DTECTALL;
  IF IDOBS NE LAG(IDOBS) THEN DO;
    DO I=1 TO 10;
      FOVDET=0; NUMFOV=0; STPCNT=0;
      END;
    END;
****** DO FOR EACH OF TEN TARGETS ************;
  DO I=1 TO 10;
    IF IDTGT=TARGET AND DTAZ=. THEN GO TO M;
        *(CANNOT COMPUTE FOVDET WITHOUT DTAZ.  SELECT NEXT TARGET.)  ;
    IF STPCNT=1 THEN GO TO M; *(STOP INCREMENTING TIME AT FIRST DETECT);
    TIMIN=0;
    NUMIN=0;
    IF IDTGT=TARGET AND FIRSTDET EQ 1 THEN STPCNT=1; *(STOP TIME FLAG);
****** FOR EACH SECOND IN SEARCH PERIDO ************;
    DO J=STSEARCH TO DETECTIM;
      K=J;
      IF AZ = 0 THEN GO TO L;  *(SKIP TO NEXT AZIMUTH);
      IF FOV=1 THEN FOVHALF=1.25;
      IF FOV=2 THEN FOVHALF=7.5;
      IF FOV=8 OR FOV=9 THEN FOVHALF=4;
*********** QUALITY CHECK ON AZIMUTH AT DETECTION *********;
      IF J=DETECTIM AND IDTGT=TARGET THEN DO;
        IF (ABS(DTAZ-AZ) GT FOVHALF) THEN AZ=DTAZ;
          *(IF A DETECTION OCCURS OUTSIDE FOV, THEN THE AZ MUST BE OFF.;
          * THEREFORE, WE SET AZ TO DTAZ AT DETECTIM.  THIS HAS THE    ;
          * EFFECT OF HAVING FOVDET >=1 FOR DETECTED TARGET)            ;
        END;
*********** END OF QUALITY CHECK *************************;
    *   AZIM=AZ;
    * AZIMOTAZ=OBSTAZ-AZIM;
      IF ABS(AZ-OTAZ) LE FOVHALF THEN DO;
        TIMIN = TIMIN + 1;  * (TIMINFOV FOR EACH ENGAGEMENT);
        FOVDET=FOVDET+1;  * (TIMINFOV FOR ACCUMULATED OVER OBS/TRIAL);
        NUM=1;  * (FLAG INDICATES WHEN TARGET IS WITHIN FOV);
        END;
      IF ABS(AZ-OTAZ) GT FOVHALF THEN NUM=0;
      IF NUM=1 THEN DO;
        IF J GT 1 THEN K=J-1;
        PREVNUM=NUM;
        IF J=1 THEN PREVNUM=0;
        IF PREVNUM=0 OR PREVNUM=. THEN DO;
          NUMIN=NUMIN+1;  * (NUMINFOV FOR EACH ENGAGEMENT);
          NUMFOV=NUMFOV+1; * (NUMINFOV ACCUMULATED OVER OBS/TRIAL);
          END;
        END;
L:    END;
M:  END;
*     IF (ABS(AZIMOTAZ) GT 1) THEN BADAZ='BAD';
*     ELSE BADAZ=' ';
*PROC PRINT;
*  VAR IDTRIAL IDOBS TARGET DETECTIM IDTGT1 TIMIN1 FOVDET1
*    IDTGT2 TIMIN2 FOVDET2 IDTGT3 TIMIN3 FOVDET3 IDTGT4 TIMIN4 FOVDET4
*    IDTGT5 TIMIN5 FOVDET5 IDTGT6 FOVDET6 IDTGT7 FOVDET7
*    IDTGT8 FOVDET8 IDTGT9 FOVDET9 IDTGT10 FOVDET10
*    AZIMOTAZ BADAZ;
*  TITLE 'DATA TWO';
***************************;
PROC SORT;
  BY IDTRIAL IDOBS;
*PROC CHART;
*  VBAR AZIMOTAZ;
*  BY IDTRIAL IDOBS;
************;
************;
DATA THREE;
  SET TWO;
***************************;
  RETAIN COUNT DETECT1-DETECT10;
  DROP AZ1-AZ600 FOV1-FOV600 NUM1-NUM600 TIMIN1-TIMIN10 NUMIN1-NUMIN10;
***************************;
  IF FIRSTDET NE 1 THEN DELETE;
  IF TARGET='UNK' THEN DELETE;
***************************;
  ARRAY DETECT (I) DETECT1-DETECT10;
  ARRAY STPCNT (I) STPCNT1-STPCNT10;
  ARRAY LAGSTP (I) LAGSTP1-LAGSTP10;
****** RESET FOR EACH OBSERVER ***********************;
  IDOBSLAG=LAG(IDOBS);
  IF IDOBS NE IDOBSLAG THEN DO;
    COUNT = 0;
    DO I=1 TO 10;
      DETECT=0;
      END;
    END;
***********************************************;
  COUNT=COUNT+1;  * (COUNTS THE ENGAGEMENTS BY EACH OBSERVER);
********* FOR EACH TARGET *******************;
```

```
  DO I = 1 TO 10;
    LAGSTP=LAG(STPCNT);  * (LAST STOP TIME FLAG FOR THIS TARGET);
    IF IDOBS NE IDOBSLAG AND STPCNT=1 THEN DETECT=1;
    IF IDOBS EQ IDOBSLAG AND STPCNT=1 AND LAGSTP=0 THEN DETECT=1;
    END;
*PROC PRINT;
*  VAR IDTRIAL IDOBS FIRSTDET DETECTIM TARGET DETTODET
*      IDTGT1 FOVDET1 DETECT1  IDTGT2 FOVDET2
*      DETECT2 IDTGT3 FOVDET3 DETECT3 IDTGT4 FOVDET4 DETECT4 IDTGT5
*      FOVDET5 DETECT5 IDTGT6 FOVDET6 DETECT6 IDTGT7 FOVDET7 DETECT7
*      IDTGT8 FOVDET8 DETECT8 IDTGT9 FOVDET9 DETECT9 IDTGT10 FOVDET10
*      DETECT10;
*  TITLE 'DATATHREE';
**********************************************;
PROC SORT;
  BY IDTRIAL IDOBS;
PROC MEANS  NOPRINT DATA=THREE MAX;
  VAR COUNT;
  BY IDTRIAL IDOBS;
  OUTPUT OUT=FOUR MAX=MAXCOUNT;
************;
************;
DATA FIVE;
  MERGE THREE FOUR;
    BY IDTRIAL IDOBS;
  RETAIN MAXCOUNT;
************;
************;
DATA SIX;
  SET FIVE;
  RETAIN CAMOUF1-CAMOUF10  EXPOSE1-EXPOSE10  ENGINE1-ENGINE10
    DTECTM1-DTECTM10  DETDET1-DETDET10  SRCHDT1-SRCHDT10;
  ARRAY IDTGT (I) IDTGT1-IDTGT10;
  ARRAY CAMOUF (I) $ CAMOUF1-CAMOUF10;
  ARRAY EXPOSE (I) $ EXPOSE1-EXPOSE10;
  ARRAY TENGINE (I) $ ENGINE1-ENGINE10;
  ARRAY SRCHDT (I) SRCHDT1-SRCHDT10;
  ARRAY DETDET (I) DETDET1-DETDET10;
  ARRAY DTECTM (I) DTECTM1-DTECTM10;
  ARRAY SIGHT (I) $ SIGHT1-SIGHT10;
  ARRAY DETECT (I) DETECT1-DETECT10;
  ARRAY FOVDET (I) FOVDET1-FOVDET10;
  ARRAY DTECTD (I) $ DTECTD1-DTECTD10;
  ARRAY NRANGE (I) $ NRANGE1-NRANGE10;
************ DO FOR EACH TARGET ************;
  IDOBSLAG=LAG(IDOBS);
  DO I = 1 TO 10;
    CAMOUF=CAMOUFLG;  TENGINE=ENGINE;  EXPOSE=TGTEXPOS;
    NRANGE=NOMRANGE;
    SIGHT=' NO';
    IF DETECT=0 THEN DO;
      DTECTD=' NO';
      DTECTM=.;  DETDET=.;  SRCHDT=.;  FOVDET=.;
      END;
    IF DETECT=1 THEN DO;
      IF SRCHMODE='THM/THM' OR SRCHMODE='OPT/OPT' OR CREWMEMB='GUNR'
        THEN SIGHT='YES';
      IF SRCHMODE='OPT/OPT' OR SRCHMODE='EYE/OPT'
```

```
        OR (SRCHMODE='EYE/THM' AND CREWMEMB='TCDR') THEN DTECTD='VIS';
      IF SRCHMODE='THM/THM' OR (SRCHMODE='EYE/THM' AND CREWMEMB='GUNR')
        THEN DTECTD='THM';
  * TARGET IS THE VARIABLE NAME FROM DTECTALL RELATED TO EACH DETECTION ;
  * IDTGT1-IDTGT10 ARE THE TARGETS FROM OTAZ ORDERED FROM LEFT TO RIGHT ;
      IF TARGET = IDTGT AND FIRSTDET=1 THEN DO;
        DTECTM=DETECTIM;
        DETDET=DETTODET;
        SRCHDT=SSTTODET;
        END;
      END;
    END;
**************************************************;
  IF COUNT NE MAXCOUNT THEN DELETE;
**************************************************;
*************;
*************;
DATA SEVEN;
  SET SIX;
  ARRAY IDTGT (I) $ IDTGT1-IDTGT10;
  ARRAY LOGTIM (I) LOGTIM1-LOGTIM10;
  ARRAY DTECTM (I) DTECTM1-DTECTM10;
  ARRAY SRCHDT (I) SRCHDT1-SRCHDT10;
  ARRAY DETDET (I) DETDET1-DETDET10;
  ARRAY FOVDET (I) FOVDET1-FOVDET10;
  ARRAY DTECTD (I) $ DTECTD1-DTECTD10;
  TOTDTECT=0;
  DO I=1 TO 10;
    IF DTECTD NE ' NO' THEN TOTDTECT=TOTDTECT+1;
    IF FOVDET=0 THEN FOVDET=.;
    LOGTIM=LOG(FOVDET);
    IF DTECTM=0 THEN DTECTM=.;
    IF DETDET=0 THEN DETDET=.;
*   IF IDTGT='T07' AND (IDTRIAL='DS121' OR IDTRIAL='DS122' OR
*     IDTRIAL='DS123') THEN LINK BADAZ;
*   IF IDTGT='HK52' AND (IDTRIAL='DS177' OR IDTRIAL='DS178')
*     THEN LINK BADAZ;
    END;
*   RETURN;
* BADAZ: DETDET=.;
*        SRCHDT=.;
*        FOVDET=.;
*        DTECTM=.;
*   RETURN;
************************************************;
*PROC PRINT;
*  VAR IDTRIAL IDOBS TOTDTECT
*   IDTGT1 DTECTD1 DTECTM1 DETDET1 SRCHDT1 FOVDET1
*   IDTGT2 DTECTD2 DTECTM2 DETDET2 SRCHDT2 FOVDET2
*   IDTGT3 DTECTD3 DTECTM3 DETDET3 SRCHDT3 FOVDET3
*   IDTGT4 DTECTD4 DTECTM4 DETDET4 SRCHDT4 FOVDET4
*   IDTGT5 DTECTD5 DTECTM5 DETDET5 SRCHDT5 FOVDET5
*   IDTGT6 DTECTD6 DTECTM6 DETDET6 SRCHDT6 FOVDET6
*   IDTGT7 DTECTD7 DTECTM7 DETDET7 SRCHDT7 FOVDET7
*   IDTGT8 DTECTD8 DTECTM8 DETDET8 SRCHDT8 FOVDET8
*   IDTGT9 DTECTD9 DTECTM9 DETDET9 SRCHDT9 FOVDET9
*   IDTGT10 DTECTD10 DTECTM10 DETDET10 SRCHDT10 FOVDET10;
*  TITLE 'TIMINFOV LISTING';
*  TITLE2 ' ';
*  TITLE3 'TARGETS 1-10 (SORTED FROM LEFT TO RIGHT)';
*  TITLE4 'TIMES TO FIRST DETECTION OF EACH TARGET';
*  TITLE5 ' ';
*  TITLE6 'DTECTD = WHETHER TARGET WAS DETECTED (VISUAL OR THERMAL)';
*  TITLE7 'DETDET = SECONDS BETWEEN DETECTIONS';
*  TITLE8 'SRCHDT = SECONDS FROM START SEARCH TO DETECTION';
*  TITLE9 'FOVDET = SECONDS EACH TARGET CAME WITHIN FIELD OF VIEW';
*PROC PRINT;
*  VAR IDTRIAL IDOBS TRLSITE AIRTEMP SRCHMODE HATCH MOPP TOTDTECT
*    IDTGT1 TGTYPE1 RANGE1 SIGHT1 ENGINE1 VISCNT1 TMPCNT1
*    IDTGT2 TGTYPE2 RANGE2 SIGHT2 ENGINE2 VISCNT2 TMPCNT2
*    IDTGT3 TGTYPE3 RANGE3 SIGHT3 ENGINE3 VISCNT3 TMPCNT3
*    IDTGT4 TGTYPE4 RANGE4 SIGHT4 ENGINE4 VISCNT4 TMPCNT4
*    IDTGT5 TGTYPE5 RANGE5 SIGHT5 ENGINE5 VISCNT5 TMPCNT5
*    IDTGT6 TGTYPE6 RANGE6 SIGHT6 ENGINE6 VISCNT6 TMPCNT6
*    IDTGT7 TGTYPE7 RANGE7 SIGHT7 ENGINE7 VISCNT7 TMPCNT7
*    IDTGTB TGTYPE8 RANGEB SIGHT8 ENGINE8 VISCNT8 TMPCNTB
*    IDTGT9 TGTYPE9 RANGE9 SIGHT9 ENGINE9 VISCNT9 TMPCNT9
*    IDTGT10 TGTYPE10 RANGE10 SIGHT10 ENGINE10 VISCNT10 TMPCNT10;
*  TITLE3 'TARGETS 1-10 (SORTED FROM LEFT TO RIGHT)';
*  TITLE4 'TIMES TO FIRST DETECTION OF EACH TARGET';
*  TITLE5;
*  TITLE6 'SIGHT = WHETHER A SIGHT WAS USED IN DETECTION';
*  TITLE7 'VISCNT = TARGET VISUAL CONTRAST WITH 8ACKGROUND';
*  TITLEB 'TMPCNT = TARGET TEMPERATURE CONTRAST WITH BACKGROUND';
***=********;
=***********;
DATA EIGHTA:
  SET SEVEN;
  ARRAY SRCHDT (I) SRCHDT2-SRCHDTI0;
  ARRAY DETDET (I) DETDET2-DETDETI0;
  ARRAY FOVDET (I) FOVDET2-FOVDETI0;
  ARRAY FOVBIN (J) FOVBIN1-FOVBIN10;
  ARRAY SRCBIN (J) SRCBIN1-SRCBIN10;
  ARRAY DETBIN (J) DETBIN1-DETBIN10;
  DO J=I TO 10;
    FOVBIN=0;  SRCBIN=0;  DETBIN=0;
    END;
*** THIS PUTS FOVDET AND SRCHDT TIMES INTO BINS OF INTERVAL I6 *******;
  DO I=1 TO 9;
    LOLIMIT=0;   UPLIMIT=16;
    DO J=I TO I0;
      IF UPLIMIT LT 250 THEN DO;
    IF (FOVDET GT LOLIMIT) AND (FOVDET LE UPLIMIT) THEN FOVBIN=FOVBIN+I;
    IF (SRCHDT GT LOLIMIT) AND (SRCHDT LE UPLIMIT) THEN SRCBIN=SRCBIN+I;
        LOLIMIT=LOLIMIT+16;
        UPLIMIT=UPLIMIT+16;
        END;
      END;
    END:
**=****** THIS ROUTINE PUTS DETDET TIMES INTO BINS OF INTERVAL 20 *****;
  DO I=I TO 9:
    LOLIMIT=0;   UPLIMIT=20;
    DO J=1 TO 10;
      IF UPLIMIT LT 300 THEN DO;
    IF (DETDET GT LOLIMIT) AND (DETDET LE UPLIMIT) THEN DETBIN=DETBIN+1;
        LOLIMIT=LOLIMIT+20;
    UPLIMIT*UPLIMIT+20;
    END;
   END;
  END;
*PRDC MEANS NDPRINT;
*  VAR FDVBIN1 FDVBIN2 FDVBIN3 FOVBIN4 FDVBIN5 FDV8IN6 FDVBIN7 FDVBIN8
*      FDVBIN9 FDVBIN10
*      SRCBIN1 SRCBIN2 SRCBIN3 SRCBIN4 SRC8IN5 SRCBIN6 SRCBIN7 SRCBIN8
*      SRCBIN9 SRCBIN10
*      DET8IN1 DETBIN2 DETBIN3 DETBIN4 DETBIN5 DETBIN6 DETBIN7 DETBIN8
*      DETBIN9 DETBIN10;
*  DUTPUT DUT=EIGHTB SUM=SUMFDV1 SUMFDV2 SUMFDV3 SUMFDV4 SUMFDV5 SUMFDV6
*      SUMFDV7 SUMFOV8 SUMFOV9 SUMFDV10
*      SUMSRC1 SUMSRC2 SUMSRC3 SUMSRC4 SUMSRC5 SUMSRC6
*      SUMSRC7 SUMSRC8 SUMSRC9 SUMSRC10
*      SUMDET1 SUMDET2 SUMDET3 SUMDET4 SUMDET5 SUMDET6
*      SUMDET7 SUMDET8 SUMDET9 SUMDET10;
*PRDC PRINT;
*  VAR SUMFOV1 SUMFOV2 SUMFOV3 SUMFDV4 SUMFDV5 SUMFOV6
*      SUMFDV7 SUMFDV8 SUMFDV9 SUMFOV10
*      SUMSRC1 SUMSRC2 SUMSRC3 SUMSRC4 SUMSRC5 SUMSRC6
*      SUMSRC7 SUMSRC8 SUMSRC9 SUMSRC10
*      SUMDET1 SUMDET2 SUMDET3 SUMDET4 SUMDET5 SUMDET6
*      SUMDET7 SUMDETB SUMDET9 SUMDET10;
*  TITLE 'GEDMETRICAL DRDER';
************;
************;
DATA TEN;
  SET SEVEN;
*PROC CHART;
*  V8AR FDVDET1 FDVDET2 FOVDET3 FDVDET4 FOVDET5 FOVDET6 FDVDET7 FOVDET8
*    FDVDET9 FOVDET10 /TYPE=PERCENT
*              MIDPOINTS=8 24 40 56 72 88 104 120 136 152 168 184;
*  TITLE1 'TIMINFDV LISTING';
*  TITLE2 ' ';
*  TITLE3 'DISTRIBUTIDN DF FDV-TO-DET BY PDSITIDN';
*  TITLE4 '(SECDNDS EACM TARGET CAME WITMIN FDV UNTIL DETECTION)';
*  TITLE5 ' ';
*  TITLE6 'TARGETS SDRTED FRDM LEFT TO RIGHT';
*PRDC CHART:
*  VBAR SRCHDT1 SRCHDT2 SRCHDT3 SRCHDT4 SRCHDT5 SRCHDT6 SRCHDT7 SRCHDT8
*     SRCHDT9 SRCHDT10 /TYPE=PERCENT
*              MIDPOINTS=8 24 40 56 72 88 104 120 136 152 168 184;
*  TITLE3 'DISTRI8UTION DF SEARCH-TO-DET 8Y POSITION';
*  TITLE4 '(SECONDS FROM START SEARCH TD DETECTION)';
*  TITLE5 ' ';
*  TITLE6 'TARGETS SORTED FROM LEFT TD RIGHT';
*PROC CHART;
*  VBAR DETDET1 DETDET2 DETDET3 DETDET4 DETDET5 DETDET6 DETDET7 DETDET8
*     DETDET9 DETDET10 /TYPE=PERCENT
*              MIDPDINTS=10 30 50 70 90 110 130 150 170 190;
*  TITLE3 'DISTRIBUTION OF DET-TO-DET 8Y POSITION';
*  TITLE4 '(SECONDS 8ETWEEN DETECTIONS)';
*  TITLE5 ' ';
*  TITLE6 'TARGETS SDRTED FROM LEFT TO RIGHT';
*PROC UNIVARIATE;
* VAR FOVDET1 FOVDET2 FOVDET3 FDVDET4 FDVDET5 FDVDET6 FOVDET7 FOVDET8
*    FOVDET9 FOVDET10
*    SRCMDT1 SRCMDT2 SRCHDT3 SRCMDT4 SRCHDT5 SRCMDT6 SRCMDT7 SRCMDT8
*    SRCMDT9 SRCHDT10
*    DETDETI DETDET2 DETDET3 DETDET4 DETDET5 DETDET6 DETDET7 DETDET8
*    DETDET9 DETDET10;
* TITLE1 'TARGETS SORTED LEFT TO RIGMT';
*PROC CMART;
*  VBAR DETDETI DETECT2 DETECT3 DETECT4 DETECT5 DETECT6 DETECT7 DETECT8
*    DETECT9 DETECT10 /TYPE=PERCENT;
*  TITLE 'TARGETS SORTED LEFT TO RIGHT';
*************;
*************;
DATA EIGMT;
  SET SEVEN;
  ARRAY DTECTM (I) DTECTMI-DTECTMI0;
********** SORT VARIABLES BY DETECTIM ********************;
  DD I=I TO I0;
    IF DTECTM=. TMEN DTECTM=999;
    END;
  CMNGFLAG=I;
  DO WMILE (CMNGFLAG=1);
    CHNGFLAG=0;
    IF (DTECTMI GT DTECTM2) THEN DO;
      DTECTMIA=DTECTM1;  DTECTM1=DTECTM2;  DTECTM2=DTECTMIA;
      IDTGT1A=IDTGTI;    IDTGT1=IDTGT2;    IDTGT2=IDTGT1A;
      RANGEIA=RANGEI;    RANGEI=RANGE2;    RANGE2=RANGEIA;
      NRANGEIA=NRANGE1;  NRANGE1=NRANGE2;  NRANGE2=NRANGE1A;
      TMPCNTIA=TMPCNT1;  TMPCNT1=TMPCNT2;  TMPCNT2=TMPCNT1A;
      VISCNTIA=VISCNT1;  VISCNT1=VISCNT2;  VISCNT2=VISCNT1A;
      CONDIT1A=CONDIT1;  CONDIT1=CONDIT2;  CONDIT2=CONDIT1A;
      TGTYPEIA=TGTYPEI;  TGTYPE1=TGTYPE2;  TGTYPE2=TGTYPE1A;
      DTECTD1A=DTECTD1;  DTECTDI=DTECTD2;  DTECTD2=DTECTDIA;
      DETECTIA=DETECTI;  DETECT1=DETECT2;  DETECT2=DETECTIA;
       SIGMTIA=SIGMT1;    SIGMT1=SIGMT2;    SIGMT2=SIGHT1A;
      DETDETIA=DETDETI;  DETDETI=DETDET2;  DETDET2=DETDETIA;
      SRCMDTIA=SRCMDTI;  SRCHDT1=SRCMDT2;  SRCMDT2=SRCMDTIA;
      FOVDETIA=FDVDETI;  FDVDETI=FOVDET2;  FOVDET2=FDVDETIA;
      NUMFOVIA=NUMFOVI;  NUMFOV1=NUMFOV2;  NUMFDV2=NUMFDVIA;
      CMNGFLAG=I;  END;
    IF (DTECTM2 GT DTECTM3) TMEN DD;
      DTECTM2A=DTECTM2;      DTECTM2=DTECTM3;      DTECTM3=DTECTM2A;
      IDTGT2A=IDTGT2;    IDTGT2=IDTGT3;    IDTGT3=IDTGT2A;
      RANGE2A=RANGE2;    RANGE2=RANGE3;    RANGE3=RANGE2A;
      NRANGE2A=NRANGE2;  NRANGE2=NRANGE3;  NRANGE3=NRANGE2A;
      TMPCNT2A=TMPCNT2;  TMPCNT2=TMPCNT3;  TMPCNT3=TMPCNT2A;
      VISCNT2A=VISCNT2;  VISCNT2=VISCNT3;  VISCNT3=VISCNT2A;
      CONDIT2A=CONDIT2;  CONDIT2=CONDIT3;  CONDIT3=CONDIT2A;
      TGTYPE2A=TGTYPE2;  TGTYPE2=TGTYPE3;  TGTYPE3=TGTYPE2A;
      DTECTD2A=DTECTD2;  DTECTD2=DTECTD3;  DTECTD3=DTECTD2A;
      DETECT2A=DETECT2;  DETECT2=DETECT3;  DETECT3=DETECT2A;
       SIGHT2A=SIGHT2;    SIGMT2=SIGMT3;    SIGHT3=SIGMT2A;
      DETDET2A=DETDET2;  DETDET2=DETDET3;  DETDET3=DETDET2A;
      SRCHDT2A=SRCMDT2;  SRCMDT2=SRCHDT3;  SRCHDT3=SRCMDT2A;
      FOVDET2A=FOVDET2;  FOVDET2=FOVDET3;  FOVDET3=FOVDET2A;
      NUMFOV2A=NUMFOV2;  NUMFOV2=NUMFOV3;  NUMFOV3=NUMFOV2A;
      CHNGFLAG=1;  END;
    IF (DTECTM3 GT DTECTM4) TMEN DO;
      DTECTM3A=DTECTM3;      DTECTM3=DTECTM4;      DTECTM4=DTECTM3A;
      IDTGT3A=IDTGT3;    IDTGT3=IDTGT4;    IDTGT4=IDTGT3A;
  RANGE3A=RANGE3;     RANGE3=RANGE4;     RANGE4=RANGE3A;
  NRANGE3A=NRANGE3;   NRANGE3=NRANGE4;   NRANGE4=NRANGE3A;
  TMPCNT3A=TMPCNT3;   TMPCNT3=TMPCNT4;   TMPCNT4=TMPCNT3A;
  VISCNT3A=VISCNT3;   VISCNT3=VISCNT4;   VISCNT4=VISCNT3A;
  CONDIT3A=CONDIT3;   CDNDIT3=CDNOIT4;   CONOIT4=CONOIT3A;
  TGTYPE3A=TGTYPE3;   TGTYPE3=TGTYPE4;   TGTYPE4=TGTYPE3A;
  DTECTO3A=DTECTD3;   DTECTD3=DTECTO4;   DTECTD4=OTECTD3A;
  DETECT3A=DETECT3;   DETECT3=DETECT4;   DETECT4=DETECT3A;
   SIGHT3A=SIGHT3;     SIGHT3=SIGHT4;     SIGHT4=SIGHT3A;
  OETDET3A=DETDET3;   DETDET3=DETDET4;   DETDET4=DETDET3A;
  SRCHDT3A=SRCHDT3;   SRCHDT3=SRCHOT4;   SRCHDT4=SRCHDT3A;
  FOVOET3A=FOVDET3;   FOVOET3=FOVOET4;   FOVDET4=FOVDET3A;
  NUMFOV3A=NUMFOV3;   NUMFOV3=NUMFOV4;   NUMFOV4=NUMFOV3A;
  CHNGFLAG=1;  ENO;
IF (DTECTM4 GT OTECTM5) THEN DD;
  DTECTM4A=DTECTM4;       DTECTM4=DTECTM5;       DTECTM5=OTECTM4A;
  IOTGT4A=IDTGT4;     IDTGT4=IOTGT5;     IOTGT5=IDTGT4A;
  RANGE4A=RANGE4;     RANGE4=RANGE5;     RANGE5=RANGE4A;
  NRANGE4A=NRANGE4;   NRANGE4=NRANGE5;   NRANGE5=NRANGE4A;
  TMPCNT4A=TMPCNT4;   TMPCNT4=TMPCNT5;   TMPCNT5=TMPCNT4A;
  VISCNT4A=VISCNT4;   VISCNT4=VISCNT5;   VISCNT5=VISCNT4A;
  CONOIT4A=CONOIT4;   CONOIT4=CONOIT5;   CONOIT5=CDNOIT4A;
  TGTYPE4A=TGTYPE4;   TGTYPE4=TGTYPE5;   TGTYPE5=TGTYPE4A;
  DTECTO4A=DTECTD4;   DTECTD4=DTECTD5;   OTECTD5=OTECTO4A;
  OETECT4A=OETECT4;   DETECT4=OETECT5;   DETECT5=DETECT4A;
   SIGHT4A=SIGHT4;     SIGHT4=SIGHT5;     SIGHT5=SIGHT4A;
  DETDET4A=OETOET4;   DETDET4=DETOET5;   DETDET5=OETDET4A;
  SRCHOT4A=SRCHDT4;   SRCHDT4=SRCHDT5;   SRCHDT5=SRCHDT4A;
  FOVOET4A=FOVDET4;   FOVDET4=FDVDET5;   FDVDET5=FOVDET4A;
  NUMFDV4A=NUMFOV4;   NUMFOV4=NUMFOV5;   NUMFOV5=NUMFOV4A;
  CHNGFLAG=1;  ENO;
IF (DTECTM5 GT DTECTM6) THEN DD;
  DTECTM5A=DTECTM5;       DTECTM5=DTECTM6;       DTECTM6=DTECTM5A;
  IDTGT5A=IDTGT5;     IDTGT5=IDTGT6;     IDTGT6=IOTGT5A;
  RANGE5A=RANGE5;     RANGE5=RANGE6;     RANGE6=RANGE5A;
  NRANGE5A=NRANGE5;   NRANGE5=NRANGE6;   NRANGE6=NRANGE5A;
  TMPCNT5A=TMPCNT5;   TMPCNT5=TMPCNT6;   TMPCNT6=TMPCNT5A;
  VISCNT5A=VISCNT5;   VISCNT5=VISCNT6;   VISCNT6=VISCNT5A;
  CDNDIT5A=CONDIT5;   CDNDIT5=CONOIT6;   CONOIT6=CONOIT5A;
  TGTYPE5A=TGTYPE5;   TGTYPE5=TGTYPE6;   TGTYPE6=TGTYPE5A;
  OTECTO5A=DTECTD5;   DTECTO5=OTECTD6;   DTECTD6=OTECTO5A;
  DETECT5A=DETECT5;   DETECT5=DETECT6;   DETECT6=OETECT5A;
   SIGHT5A=SIGHT5;     SIGHT5=SIGHT6;     SIGHT6=SIGHT5A;
  DETOET5A=DETOET5;   DETDET5=OETDET6;   OETDET6=DETDET5A;
  SRCHOT5A=SRCHDT5;   SRCHDT5=SRCHOT6;   SRCHOT6=SRCHDT5A;
  FOVOET5A=FOVDET5;   FOVOET5=FOVDET6;   FOVOET6=FOVDET5A;
  NUMFOV5A=NUMFOV5;   NUMFOV5=NUMFOV6;   NUMFOV6=NUMFOV5A;
  CHNGFLAG=1;  END;
IF (DTECTM6 GT DTECTM7) THEN DD;
  OTECTM6A=OTECTM6;       OTECTM6=DTECTM7;       OTECTM7=DTECTM6A;
  IOTGT6A=IOTGT6;     IDTGT6=IDTGT7;     IDTGT7=IOTGT6A;
  RANGE6A=RANGE6;     RANGE6=RANGE7;     RANGE7=RANGE6A;
  NRANGE6A=NRANGE6;   NRANGE6=NRANGE7;   NRANGE7=NRANGE6A;
  TMPCNT6A=TMPCNT6;   TMPCNT6=TMPCNT7;   TMPCNT7=TMPCNT6A;
  VISCNT6A=VISCNT6;   VISCNT6=VISCNT7;   VISCNT7=VISCNT6A;
  CONOIT6A=CONOIT6;   CONOIT6=CDNOIT7;   CDNOIT7=CONDIT6A;
  TGTYPE6A=TGTYPE6;   TGTYPE6=TGTYPE7;   TGTYPE7=TGTYPE6A;
  OTECTO6A=OTECTO6;   DTECTO6=OTECTD7;   OTECTO7=OTECTD6A;
  DETECT6A=DETECT6;   DETECT6=DETECT7;   DETECT7=DETECT6A;
   SIGHT6A=SIGHT6;     SIGHT6=SIGHT7;     SIGHT7=SIGHT6A;
  DETDET6A=DETDET6;   DETDET6=DETDET7;   DETDET7=DETDET6A;
  SRCHDT6A=SRCHDT6;   SRCHDT6=SRCHDT7;   SRCHDT7=SRCHDT6A;
  FOVDET6A=FOVDET6;   FOVDET6=FOVDET7;   FOVDET7=FOVDET6A;
  NUMFOV6A=NUMFOV6;   NUMFOV6=NUMFOV7;   NUMFOV7=NUMFOV6A;
  CHNGFLAG=1;  END;
IF (DTECTH7 GT DTECTM8) THEN DO;
  DTECTH7A=DTECTH7;      DTECTM7=DTECTM8;      DTECTM8=DTECTH7A;
  IDTGT7A=IDTGT7;     IDTGT7=IDTGT8;     IDTGT8=IDTGT7A;
  RANGE7A=RANGE7;     RANGE7=RANGE8;     RANGE8=RANGE7A;
  NRANGE7A=NRANGE7;   NRANGE7=NRANGE8;   NRANGE8=NRANGE7A;
  THPCNT7A=THPCNT7;   TMPCNT7=THPCNT8;   TMPCNT8=TMPCNT7A;
  VISCNT7A=VISCNT7;   VISCNT7=VISCNT8;   VISCNT8=VISCNT7A;
  CONDIT7A=CONDIT7;   CONDIT7=CONDIT8;   CONDIT8=CONDIT7A;
  TGTYPE7A=TGTYPE7;   TGTYPE7=TGTYPE8;   TGTYPE8=TGTYPE7A;
  DTECTD7A=DTECTD7;   DTECTD7=DTECTD8;   DTECTD8=DTECTD7A;
  DETECT7A=DETECT7;   DETECT7=DETECT8;   DETECT8=DETECT7A;
   SIGHT7A=SIGHT7;     SIGHT7=SIGHT8;     SIGHT8=SIGHT7A;
  DETDET7A=DETDET7;   DETDET7=DETDET8;   DETDET8=DETDET7A;
  SRCHDT7A=SRCHDT7;   SRCHDT7=SRCHDT8;   SRCHDT8=SRCHDT7A;
  FOVDET7A=FOVDET7;   FOVDET7=FOVDET8;   FOVDET8=FOVDET7A;
  NUHFDV7A=NUMFDV7;   NUHFDV7=NUMFDV8;   NUHFDV8=NUMFOV7A;
  CHNGFLAG=1;  END;
IF (DTECTM8 GT DTECTH9) THEN DO;
  DTECTM8A=DTECTM8;      DTECTM8=DTECTH9;      DTECTH9=DTECTM8A;
  IDTGT8A=IDTGT8;     IDTGT8=IDTGT9;     IDTGT9=IDTGT8A;
  RANGE8A=RANGE8;     RANGE8=RANGE9;     RANGE9=RANGE8A;
  NRANGE8A=NRANGE8;   NRANGE8=NRANGE9;   NRANGE9=NRANGE8A;
  TMPCNT8A=TMPCNT8;   TMPCNT8=TMPCNT9;   TMPCNT9=TMPCNT8A;
  VISCNT8A=VISCNT8;   VISCNT8=VISCNT9;   VISCNT9=VISCNT8A;
  CDNDIT8A=CONDIT8;   CDNDIT8=CONDIT9;   CONDIT9=CDNDIT8A;
  TGTYPE8A=TGTYPE8;   TGTYPE8=TGTYPE9;   TGTYPE9=TGTYPE8A;
  DTECTD8A=DTECTD8;   DTECTD8=DTECTD9;   DTECTD9=DTECTD8A;
  DETECT8A=DETECT8;   DETECT8=DETECT9;   DETECT9=DETECT8A;
   SIGHT8A=SIGHT8;     SIGHT8=SIGHT9;     SIGHT9=SIGHT8A;
  DETDET8A=DETDET8;   DETDET8=DETDET9;   DETDET9=DETDET8A;
  SRCHDT8A=SRCHDT8;   SRCHDT8=SRCHDT9;   SRCHDT9=SRCHDT8A;
  FOVDET8A=FOVDET8;   FOVDET8=FOVDET9;   FOVDET9=FOVDET8A;
  NUMFOV8A=NUMFOV8;   NUMFDV8=NUMFDV9;   NUMFDV9=NUMFDV8A;
  CHNGFLAG=1;  END;
IF (DTECTM9 GT DTECTHI0) THEN DO;
  DTECTH9A=DTECTM9;      DTECTM9=DTECTM10;      DTECTHI0=DTECTH9A;
  IDTGT9A=IDTGT9;     IDTGT9=IDTGTI0;     IDTGTI0=IDTGT9A;
  RANGE9A=RANGE9;     RANGE9=RANGE10;     RANGEI0=RANGE9A;
  NRANGE9A=NRANGE9;   NRANGE9=NRANGE10;   NRANGEI0=NRANGE9A;
  THPCNT9A=TMPCNT9;   TMPCNT9=THPCNTI0;   THPCNTI0=TMPCNT9A;
  VISCNT9A=VISCNT9;   VISCNT9=VISCNT10;   VISCNTI0=VISCNT9A;
  CONDIT9A=CONDIT9;   CDNDIT9=CONDITI0;   CONDIT10=CDNDIT9A;
  TGTYPE9A=TGTYPE9;   TGTYPE9=TGTYPE10;   TGTYPE10=TGTYPE9A;
  DTECTD9A=DTECTD9;   DTECTD9=DTECTDI0;   DTECTDI0=DTECTD9A;
  DETECT9A=DETECT9;   DETECT9=DETECT10;   DETECT10=DETECT9A;
   SIGHT9A=SIGHT9;     SIGHT9=SIGHT10;     SIGHT10=SIGHT9A;
  DETDET9A=DETDET9;   DETDET9=DETDET10;   DETDETI0=DETDET9A;
  SRCHDT9A=SRCHDT9;   SRCHDT9=SRCHDT10;   SRCHDTI0=SRCHDT9A;
  FOVDET9A=FOVDET9;   FOVDET9=FOVDET10;   FOVDET10=FOVDET9A;
  NUMFOV9A=NUMFOV9;   NUMFOV9=NUHFOV10;   NUMFOVI0=NUMFOV9A;
  CHNGFLAG=1;  END;
```

```
    END;
  DO I=1 TO 10;
    IF DTECTM=999 THEN DTECTM=.;
    END;
*************** END OF SORT ***********************************;
*PROC PRINT;
*  VAR IDTRIAL IDOBS TOTDTECT
*    IDTGT1 DTECTD1 DTECTM1 DETDET1 SRCHDT1 FOVDET1
*    IDTGT2 DTECTD2 DTECTM2 DETDET2 SRCHDT2 FOVDET2
*    IDTGT3 DTECTD3 DTECTM3 DETDET3 SRCHDT3 FOVDET3
*    IDTGT4 DTECTD4 DTECTM4 DETDET4 SRCHDT4 FOVDET4
*    IDTGT5 DTECTD5 DTECTM5 DETDET5 SRCHDT5 FOVDET5
*    IDTGT6 DTECTD6 DTECTM6 DETDET6 SRCHDT6 FOVDET6
*    IDTGT7 DTECTD7 DTECTM7 DETDET7 SRCHDT7 FOVDET7
*    IDTGT8 DTECTD8 DTECTM8 DETDET8 SRCHDT8 FOVDET8
*    IDTGT9 DTECTD9 DTECTM9 DETDET9 SRCHDT9 FOVDET9
*    IDTGT10 DTECTD10 DTECTM10 DETDET10 SRCHDT10 FOVDET10;
* TITLE 'TIMINFOV LISTING';
* TITLE2 ' ';
* TITLE3 'TARGETS 1-10 (SORTED CHRONOLOGICALLY BY DETECTION)';
* TITLE4 'TIMES TO FIRST DETECTION OF EACH TARGET';
* TITLE5 ' ';
* TITLE6 'DTECTD = WHETHER TARGET WAS DETECTED (VISUAL OR THERMAL)';
* TITLE7 'DETDET = SECONDS BETWEEN DETECTIONS';
* TITLE8 'SRCHDT = SECONDS FROM START SEARCH TO DETECTION';
* TITLE9 'FOVDET = SECONDS EACH TARGET CAME WITHIN FIELD OF VIEW';
PROC CHART;
  VBAR FOVDET1 FOVDET2 FOVDET3 FOVDET4 FOVDET5 FOVDET6 FOVDET7 FOVDET8
     FOVDET9 FOVDET10/TYPE=PERCENT
               MIDPOINTS=8 24 40 56 72 88 104 120 136 152 168;
  TITLE1 'TIMINFOV LISTING';
  TITLE2 ' ';
  TITLE3 'DISTRIBUTION OF FOV-TO-DET BY TIME';
  TITLE4 '(SECONDS EACH TARGET CAME WITHIN FOV UNTIL DETECTION';
  TITLE5 ' ';
  TITLE6 'TARGETS SORTED CHRONOLOGICALLY';
PROC CHART;
  VBAR SRCHDT1 SRCHDT2 SRCHDT3 SRCHDT4 SRCHDT5 SRCHDT6 SRCHDT7 SRCHDT8
     SRCHDT9 SRCHDT10/TYPE=PERCENT
               MIDPOINTS=8 24 40 56 72 88 104 120 136 152 168;
  TITLE3 'DISTRIBUTION OF SEARCH-TO-DET BY TIME';
  TITLE4 '(SECONDS FROM START SEARCH TO DETECTION)';
  TITLE5 ' ';
  TITLE6 'TARGETS SORTED CHRONOLOGICALLY';
PROC CHART;
  VBAR DETDET1 DETDET2 DETDET3 DETDET4 DETDET5 DETDET6 DETDET7 DETDET8
     DETDET9 DETDET10/TYPE=PERCENT
               MIDPOINTS=10 30 50 70 90 110 130 150 170 190;
  TITLE3 'DISTRIBUTION OF DET-TO-DET BY TIME';
  TITLE4 '(SECONDS BETWEEN DETECTIONS)';
  TITLE5 ' ';
  TITLE6 'TARGETS SORTED CHRONOLOGICALLY';
*PROC UNIVARIATE;
*  VAR FOVDET1 FOVDET2 FOVDET3 FOVDET4 FOVDET5 FOVDET6 FOVDET7 FOVDET8
*      FOVDET9 FOVDET10
*      SRCHDT1 SRCHDT2 SRCHDT3 SRCHDT4 SRCHDT5 SRCHDT6 SRCHDT7 SRCHDT8
*      SRCHDT9 SRCHDT10
*      DETDET1 DETDET2 DETDET3 DETDET4 DETDET5 DETDET6 DETDET7 DETDET8
*     DETDET9 DETDET10;
*  TITLE 'TARGETS SORTED CHRONOLOGICALLY';
*PROC CHART;
*  VBAR DETECT1 DETECT2 DETECT3 DETECT4 DETECT5 DETECT6 DETECT7 DETECT8
*    DETECT9 DETECT10 /TYPE=PERCENT;
*  TITLE 'TARGETS SORTED CHRONOLOGICALLY';
*PROC CORR;
*  VAR FOVDET1 FOVDET2 FOVDET3 FOVDET4 FOVDET5 FOVDET6 FOVDET7 FOVDET8;
*  TITLE 'TARGETS SORTED CHRONOLOGICALLY';
*PROC CORR;
*  VAR SRCHDT1 SRCHDT2 SRCHDT3 SRCHDT4 SRCHDT5 SRCHDT6 SRCHDT7 SRCHDT8;
*  TITLE 'TARGETS SORTED CHRONOLOGICALLY';
*PROC CORR;
*  VAR DETDET1 DETDET2 DETDET3 DETDET4 DETDET5 DETDET6 DETDET7 DETDET8;
*  TITLE 'TARGETS SORTED CHRONOLOGICALLY';
***************;
***************;
***** THIS SECTION HANDLES THE SHORT RANGE DETECTIONS ONLY. *******;
DATA NINE;
  SET EIGHT;
  ARRAY NRANGE (I) $ NRANGE1-NRANGE10;
  DO I=1 TO 10;
    IF NRANGE='SHRT';
    END;
*PROC UNIVARIATE;
*  VAR FOVDET1 FOVDET2 FOVDET3 FOVDET4 FOVDET5 FOVDET6 FOVDET7 FOVDET8
*    FOVDET9 FOVDET10
*    SRCHDT1 SRCHDT2 SRCHDT3 SRCHDT4 SRCHDT5 SRCHDT6 SRCHDT7 SRCHDT8
*    SRCHDT9 SRCHDT10
*    DETDET1 DETDET2 DETDET3 DETDET4 DETDET5 DETDET6 DETDET7 DETDET8
*    DETDET9 DETDET10;
*  TITLE1 'TARGETS SORTED CHRONOLOGICALLY AND BY NOMINAL RANGE';
*  TITLE2 ' ';
*  TITLE3 'SHORT RANGE (900-1200 METERS)';
***************;
***************;
***** THIS SECTION HANDLES THE MEDIUM RANGE DETECTIONS ONLY. *******;
DATA TEN;
  SET EIGHT;
  ARRAY NRANGE (I) $ NRANGE1-NRANGE10;
  DO I=1 TO 10;
    IF NRANGE='MEDM';
    END;
*PROC UNIVARIATE;
*  VAR FOVDET1 FOVDET2 FOVDET3 FOVDET4 FOVDET5 FOVDET6 FOVDET7 FOVDET8
*     FOVDET9 FOVDET10
*     SRCHDT1 SRCHDT2 SRCHDT3 SRCHDT4 SRCHDT5 SRCHDT6 SRCHDT7 SRCHDT8
*     SRCHDT9 SRCHDT10
*     DETDET1 DETDET2 DETDET3 DETDET4 DETDET5 DETDET6 DETDET7 DETDET8
*     DETDET9 DETDET10;
*  TITLE1 'TARGETS SORTED CHRONOLOGICALLY AND BY NOMINAL RANGE';
*  TITLE2 ' ';
*  TITLE3 'MEDIUM RANGE (1200-2200 METERS)';
***************;
***************;
***** THIS SECTION HANDLES THE LONG RANGE DETECTIONS ONLY. *******;
DATA ELEVEN;
  SET EIGHT;
  ARRAY NRANGE (I) $ NRANGE1-NRANGE10;
  DO I=1 TO 10;
    IF NRANGE='LONG';
    END;
*PROC UNIVARIATE;
*  VAR FOVDET1 FOVDET2 FOVDET3 FOVDET4 FOVDET5 FOVDET6 FOVDET7 FOVDET8
*    FOVDET9 FOVDET10
*    SRCHDT1 SRCHDT2 SRCHDT3 SRCHDT4 SRCHDT5 SRCHDT6 SRCHDT7 SRCHDT8
*    SRCHDT9 SRCHDT10
*    DETDET1 DETDET2 DETDET3 DETDET4 DETDET5 DETDET6 DETDET7 DETDET8
*    DETDET9 DETDET10;
*  TITLE1 'TARGETS SORTED CHRONOLOGICALLY AND BY NOMINAL RANGE';
*  TITLE2 ' ';
*  TITLE3 'LONG RANGE (2200-3500 METERS)';
************;
************;
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